U.S. Navy/Marine Corps
CH-53D/E, MH-53E, and CH-46E
AN/AYQ-23(V)1
Ground Proximity Warning System (GPWS)

PMA209GPWS@navy.mil

Mini-Course

GPWS ORGANIZATION

Production Systems Team Leader

Systems Engineering

Logistics

T&E

H-53

- ***Platform Liaison***
- ***PMA-261***
- ***NADEP Cherry Pt***

H-46

- ***Platform Liaison***
- ***PMA-226 Cherry Pt***

PURPOSE

WHY ARE WE HERE?

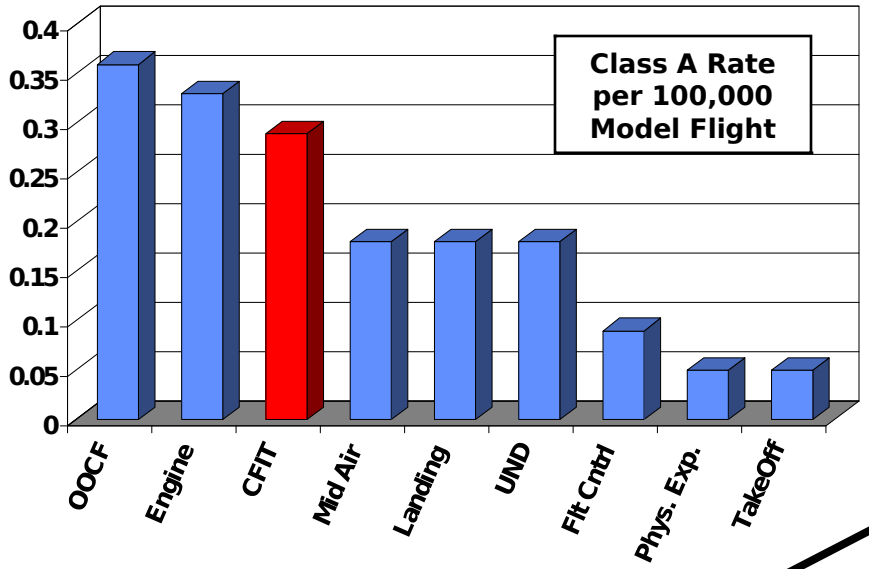
To discuss aircrew issues concerning the AN/AYQ-23(V)1 GPWS

AGENDA

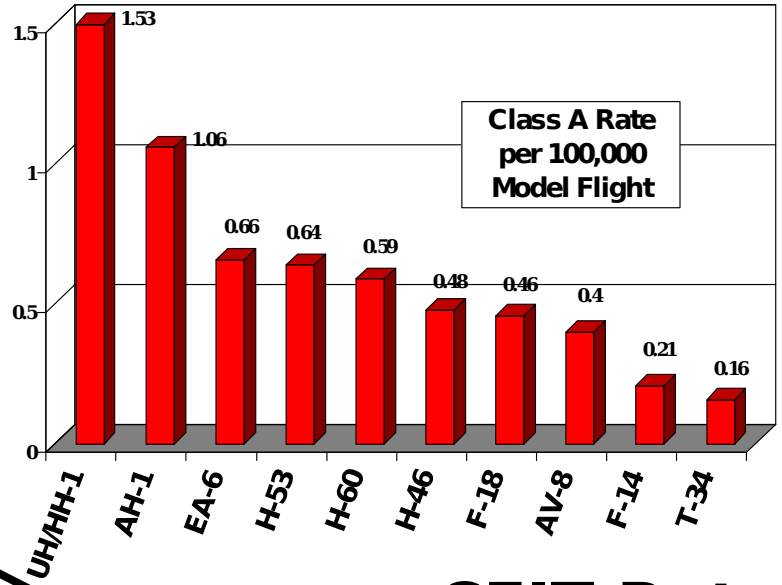
- Review of GPWS Operating Principles
- Survey results
- Status
- STR review
- Open discussion
- Wrap-up
  - Action Item review
  - Plan-of-Attack
  - Schedule

WHY GPWS?

GPWS



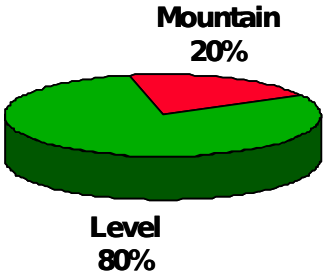
FY90 – FY00 Class A Mishaps



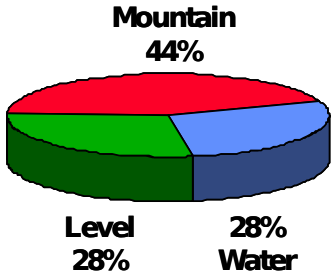
CFIT Rate By Platform FY90-FY00

CFIT Analysis By Terrain Type

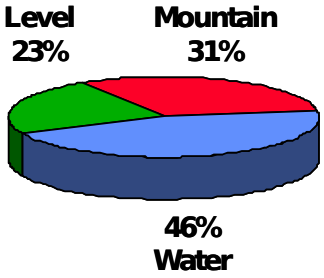
TRANSPORT, AEW, & PATROL



TACTICAL



HELICOPTER



GPWS

What Is GPWS?

GPWS - *A SAFETY BACK-UP SYSTEM* that processes real-time aircraft sensor data, and provides the crew with timely and accurate warnings of an impending controlled flight into terrain (CFIT).

GPWS

What GPWS Is Not!

GPWS is not LAWS. Per PMA-226 direction, the old LAWS tone generators were removed and the LAWS aural annunciation, controlled by the APN-171, now utilizes a spare voice annunciation in the GPWC.

GPWS is also NOT a performance aid. It is not meant to allow the crew to fly the aircraft in a purposely, overly aggressive manner until the GPWS issues a warning.

GPWS VS NON-GPWS FUNCTIONS

GPWS Function - Altitude loss after takeoff; predictive CFIT

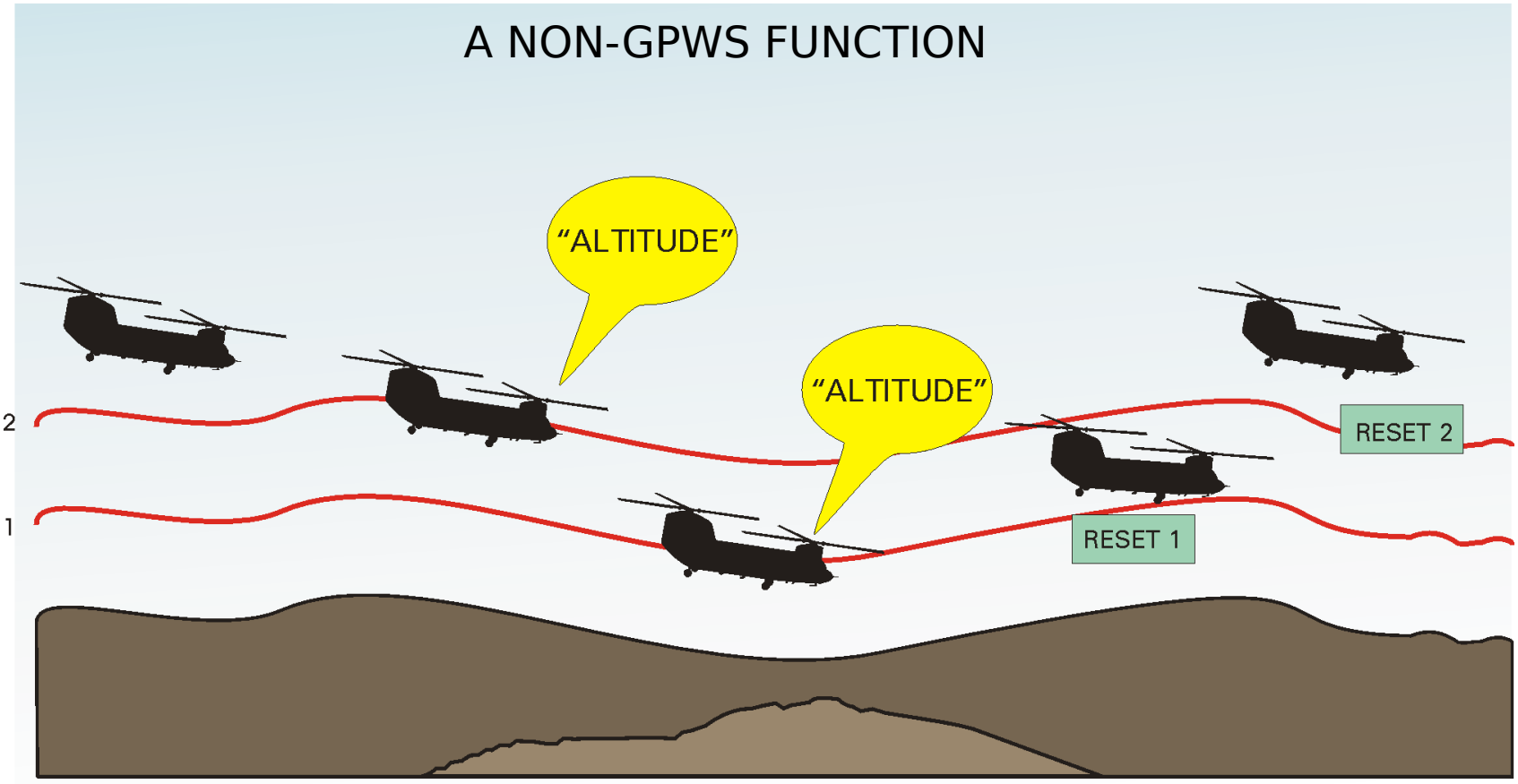
NON-GPWS Function - “Blade Stall”, “Low Fuel”, “Altitude”

Aircraft Sensor Inputs to the GPWS Processor

- Radar altimeter - data and validity
- Pitch and roll - data
- Barometric altitude* - data and validity
- Barometric altitude rate* - data and validity
- Glide slope and Localizer - data and validity (CH/MH-53E)
- Engine torque
- Indicated Airspeed

* Either Barometric altitude or Barometric altitude rate may be used

Altitude Annunciation of AN/APN-171 Bug Setting



Altitude Annunciation of AN/APN-171 Bug Setting

GPWS

This alert is issued when the aircraft descends from above to below the low altitude settings selected on either the pilot and/or co-pilot radar altimeter height indicators. If the two indicators are set such that they activate two altitude calls in a 3 second period, the second altitude call is inhibited. This call is inhibited during takeoffs and landings for the CH/MH-53s. This alert is not inhibited for the CH-46E during landing and is available at all times the GPWC and the radar altimeter are operational.

"ALTITUDE" (Call issued once)

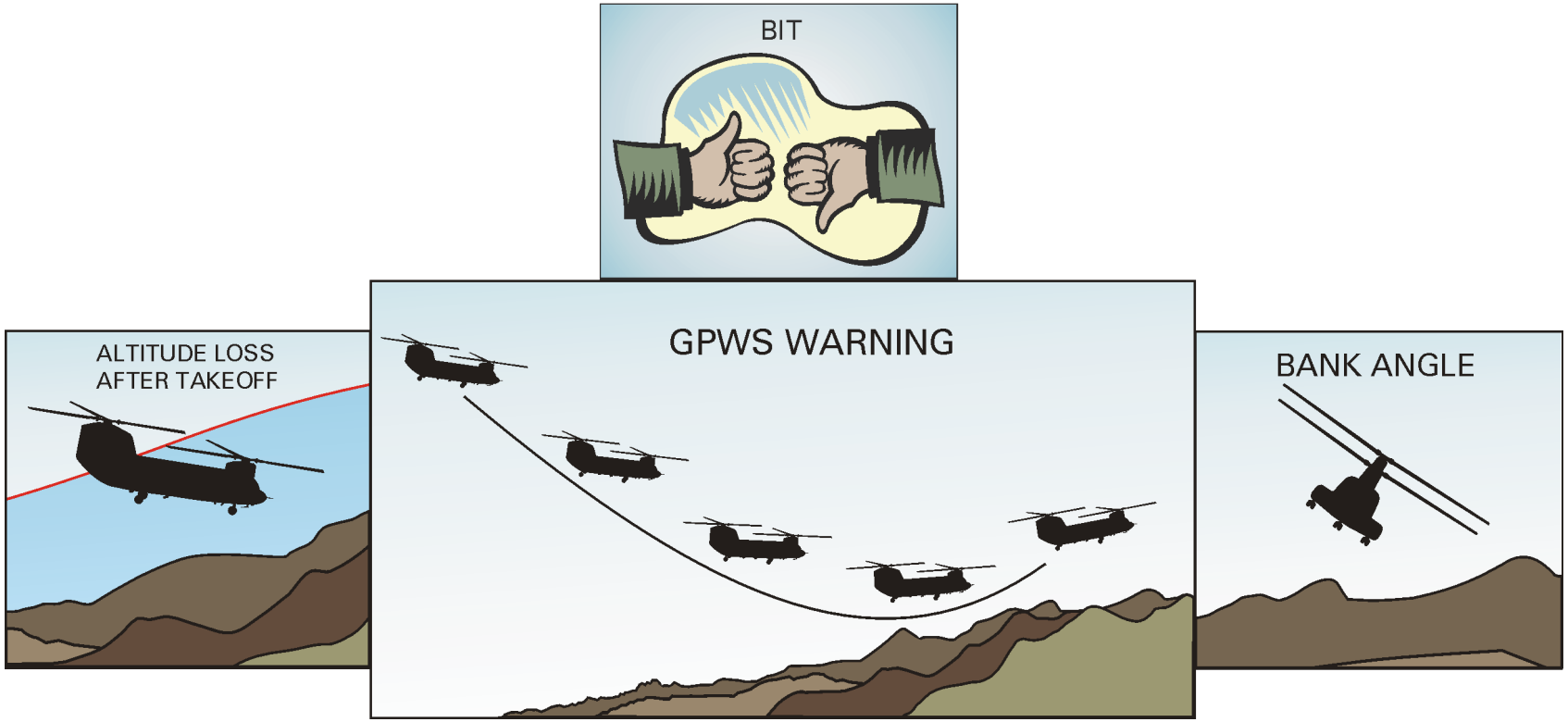
There is no visual cue other than light of RADALT Indicator

Call will not be issured again until aircraft climbs back above each index setting.

Three Basic GPWS Warnings

GPWS

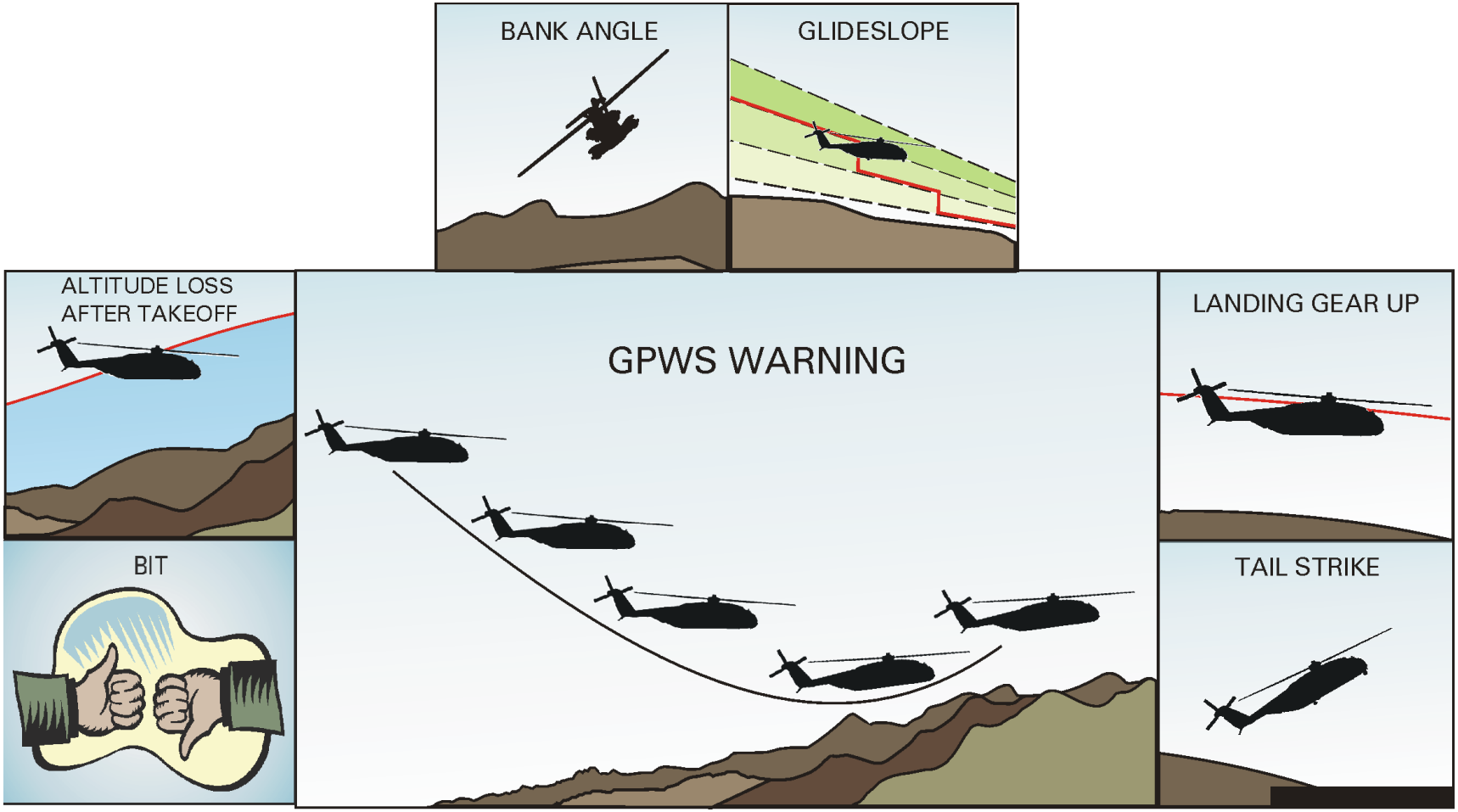
CH-46E



Six Basic GPWS Warnings

GPWS

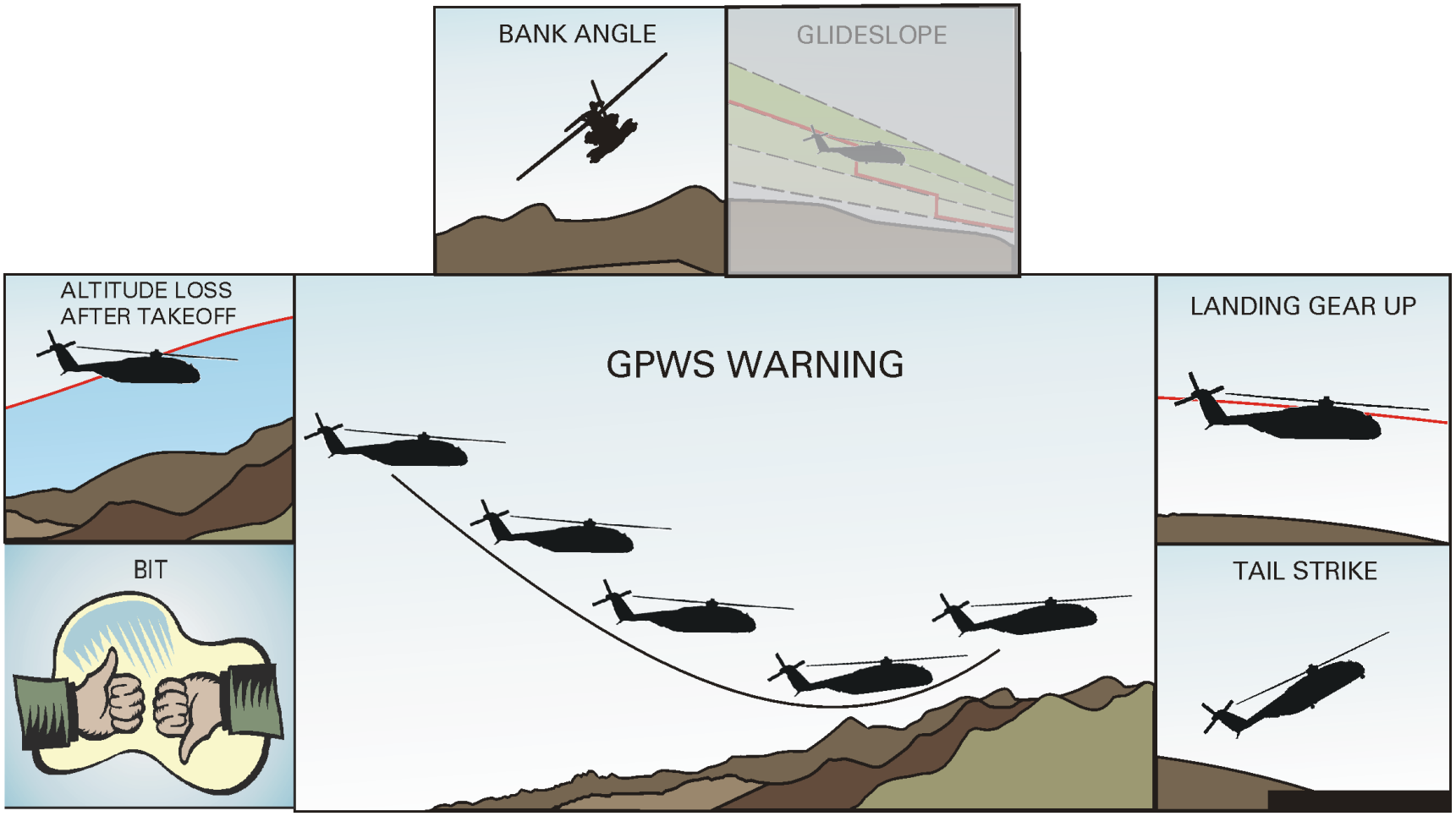
MH/CH-53E



Five Basic GPWS Warnings

GPWS

CH-53D

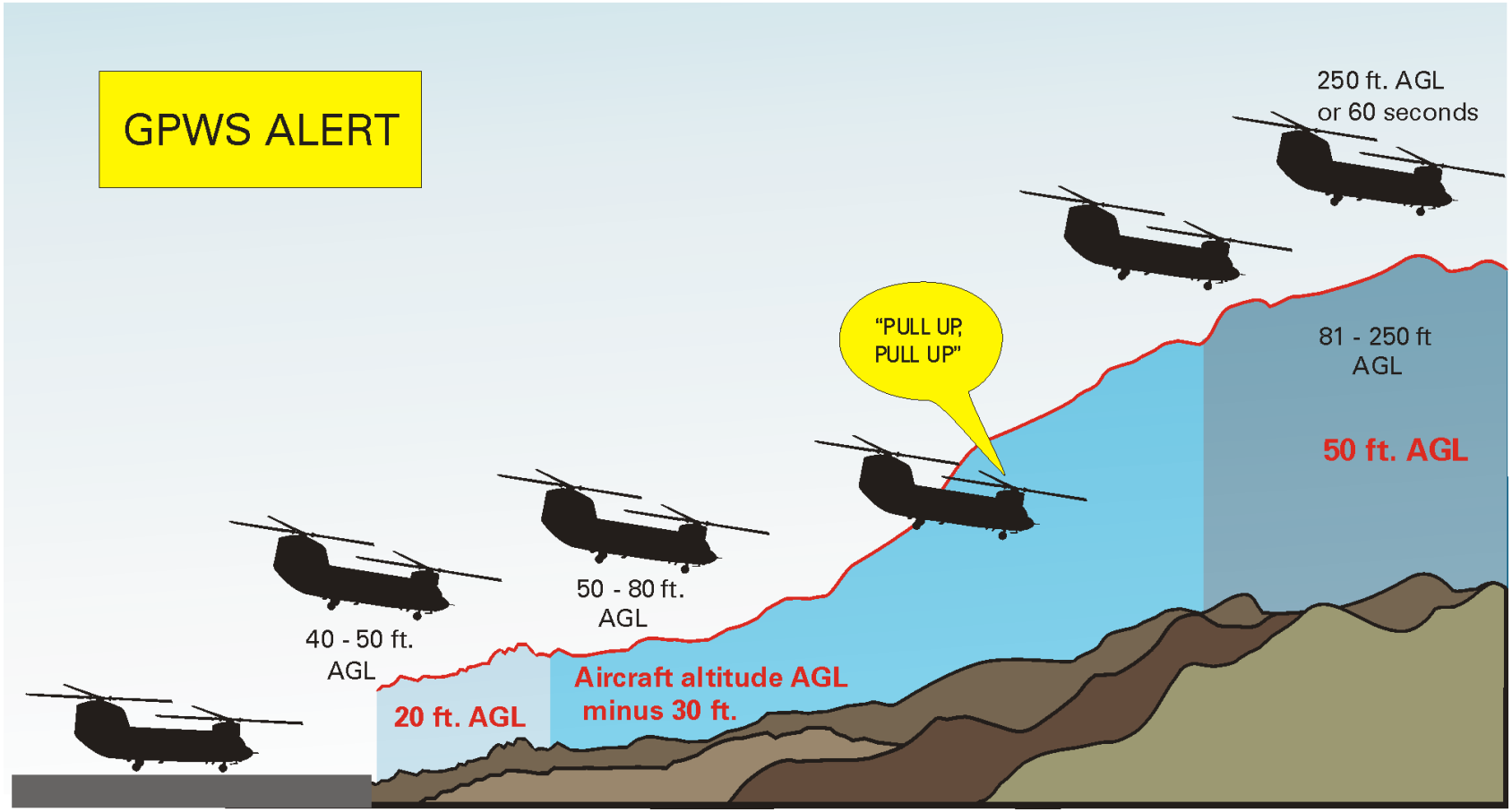


Six Basic GPWS Warnings

Condition	Warning	Frequency
Altitude Loss After Takeoff	Pull Up, Pull Up	Issued once
Impending CFIT	Whoop Whoop, Pull Up, Pull Up	Issued once
Drifting below glideslope (CH-53E/MH-53E Only)	Below Glideslope, Below Glideslope	Repeated at 3 sec intervals until condition is corrected
Excessive bank angle	Bank Angle, Bank Angle	Issued once
Trying to land with gear up CH-53D/CH-53E/MH-53E Only)	Gear, Gear	Repeated at 3 sec intervals until condition is corrected
Impending tail strike CH-53D/CH-53E/MH-53E Only)	Tail	Issued once

Altitude Loss After Takeoff

GPWS



Altitude Loss After Takeoff

GPWS

This warning is issued to prevent a CFIT shortly after takeoff and during the initial climb out. This warning protects against altitude loss due to in-air descent, rising terrain, or a combination of the two.

Aircraft's AGL Altitude	Warning Altitude
40 - 50 feet AGL	20 feet AGL
51 - 80 feet AGL	Aircraft Altitude AGL minus 30 feet
81 - 250 feet AGL	50 feet AGL

This protective mode is active for 60 seconds after takeoff or up to an altitude of 250 feet AGL, whichever comes first. After that, the predictive impending CFIT warning takes over.

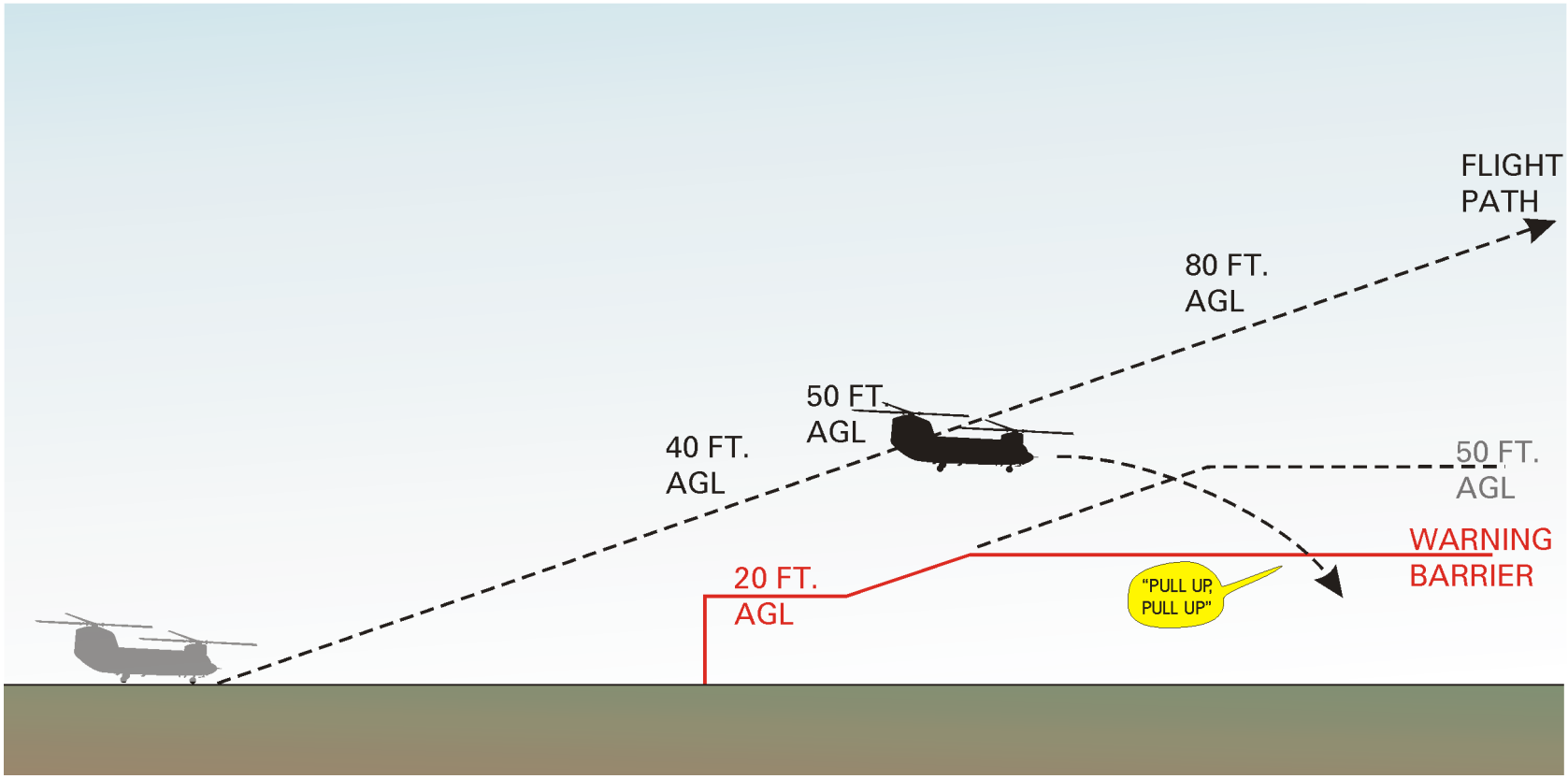
Aural warning *"PULL UP PULL UP"*

Warning issued once.

Visual warning *GPWS ALERT lamp on the Caution Advisory Panel illuminates and stays lit for the CH/MH-53 series aircraft. There is no indication for the CH-46E aircraft .*

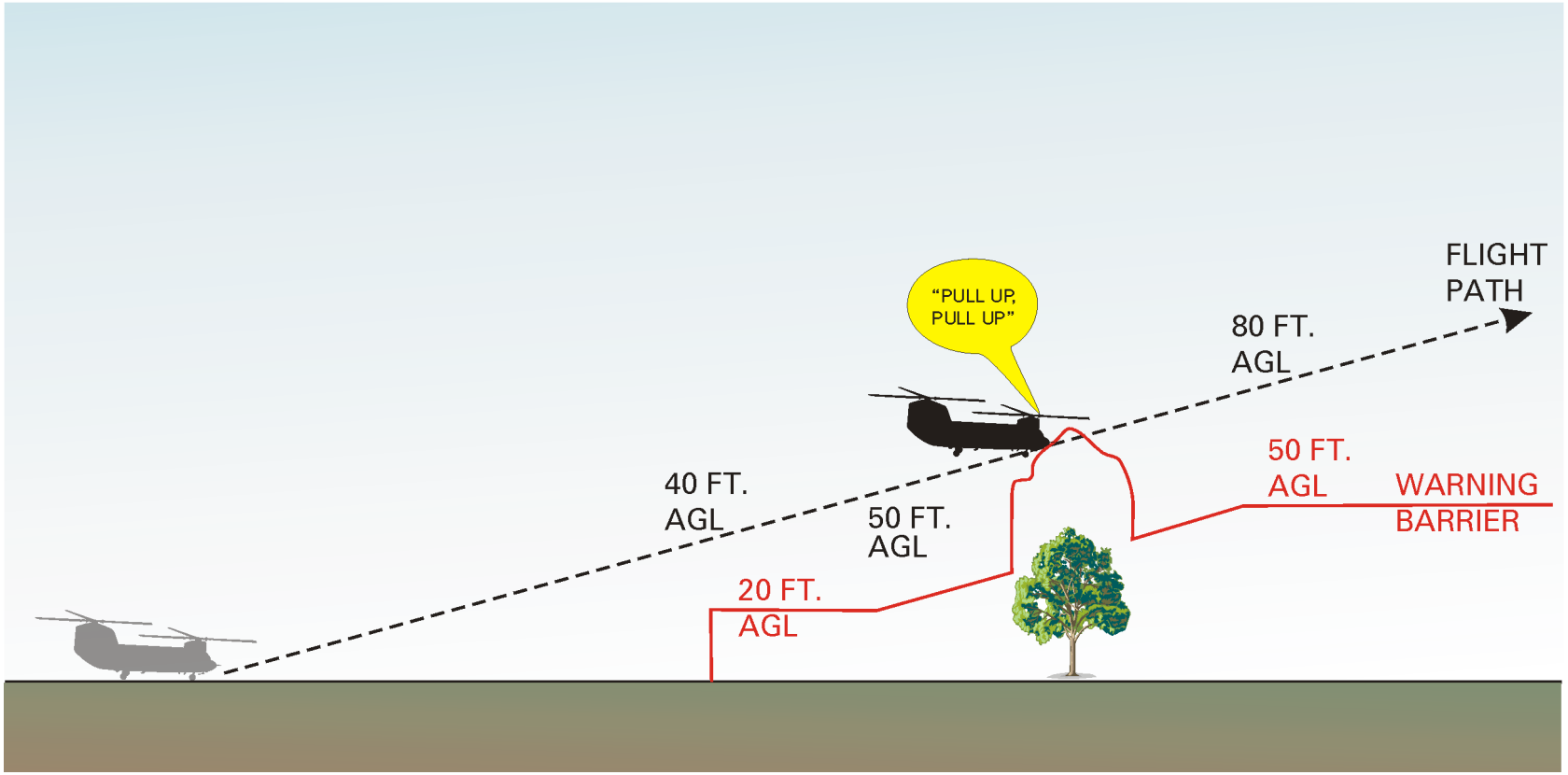
Re-arm Condition *Aircraft climbs to 80 feet AGL. The ALERT lamp is turned OFF on the CH/MH-53 aircraft.*

Altitude Loss After Takeoff



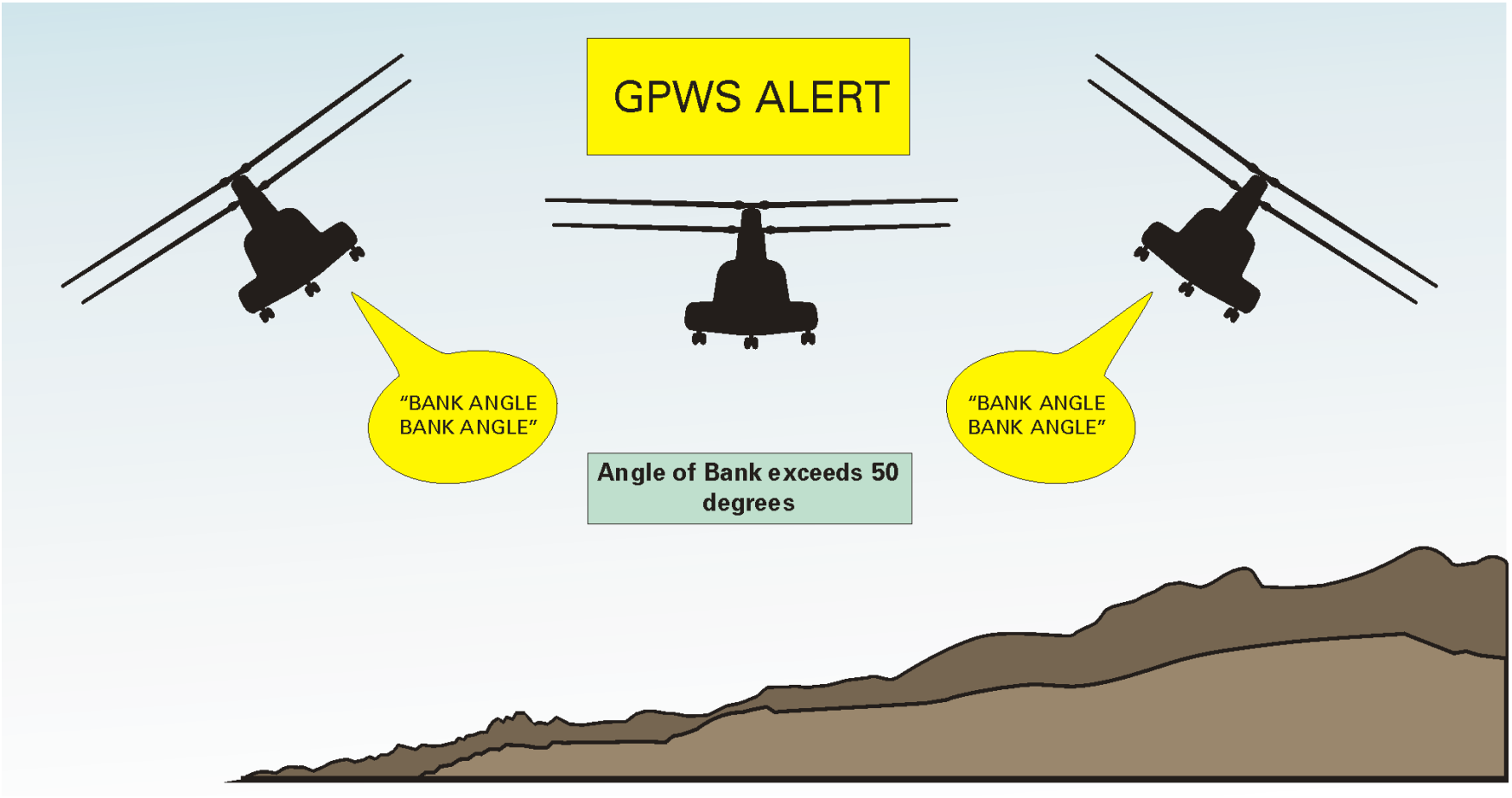
Altitude Loss After Takeoff

GPWS

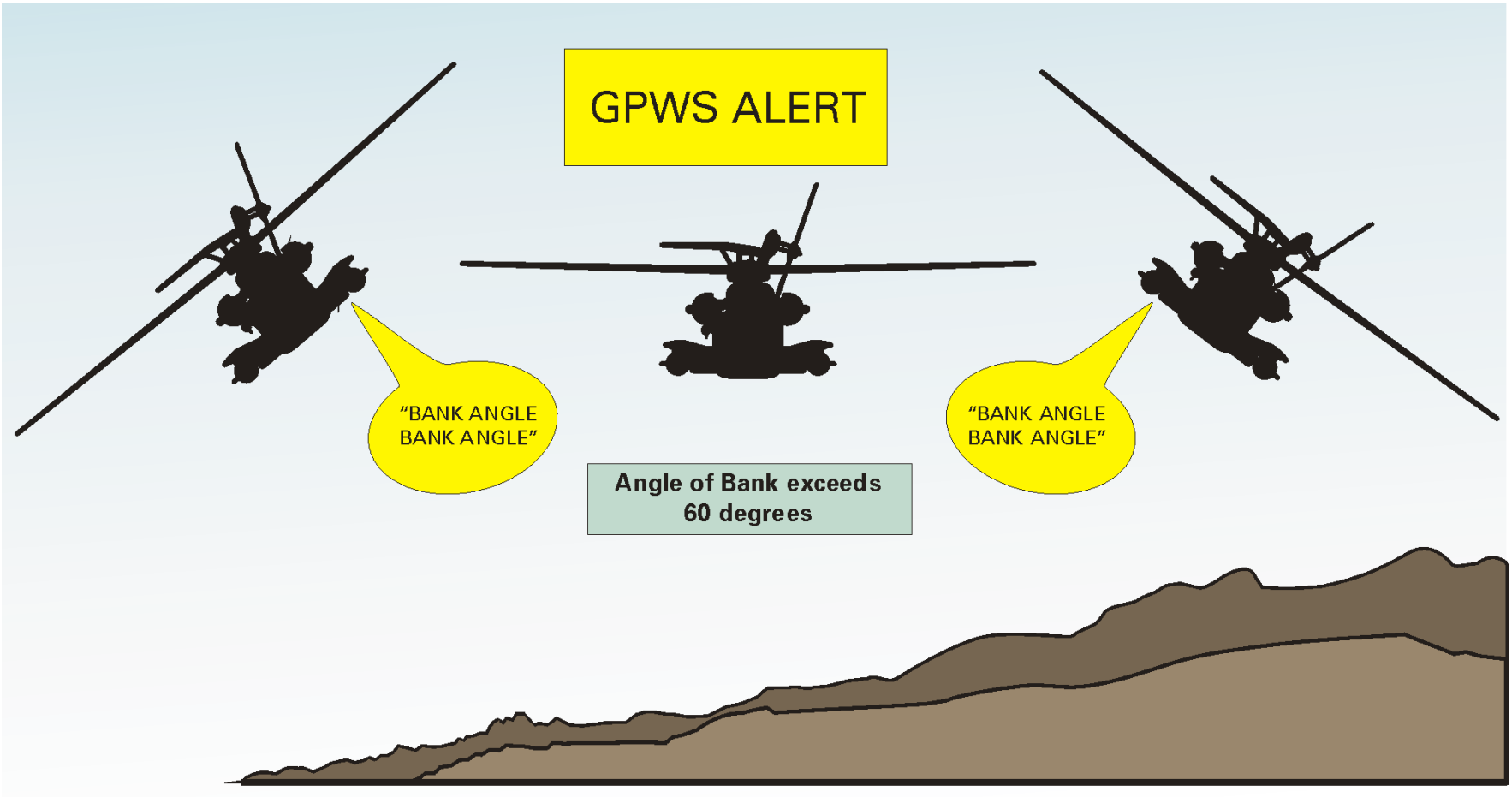


Excessive Bank Angle

GPWS



Excessive Bank Angle



Excessive Bank Angle

GPWS

This alert is issued whenever the aircraft's bank angle exceeds 50° for CH-46E aircraft or 60° for the CH/MH-53 series aircraft.

Aural alert ***"BANK ANGLE BANK ANGLE"***
Alert issued once.

Visual alert ***GPWS ALERT lamp on the Caution Advisory Panel***
illuminates and stays lit for the CH/MH-53 series aircraft. There is no indication for the CH-46E aircraft .

Re-arm Condition ***Aircraft bank angle decreases below 50° for the CH- 46E aircraft or 60° for the CH/MH-53 series aircraft or less. The ALERT lamp is turned OFF.***

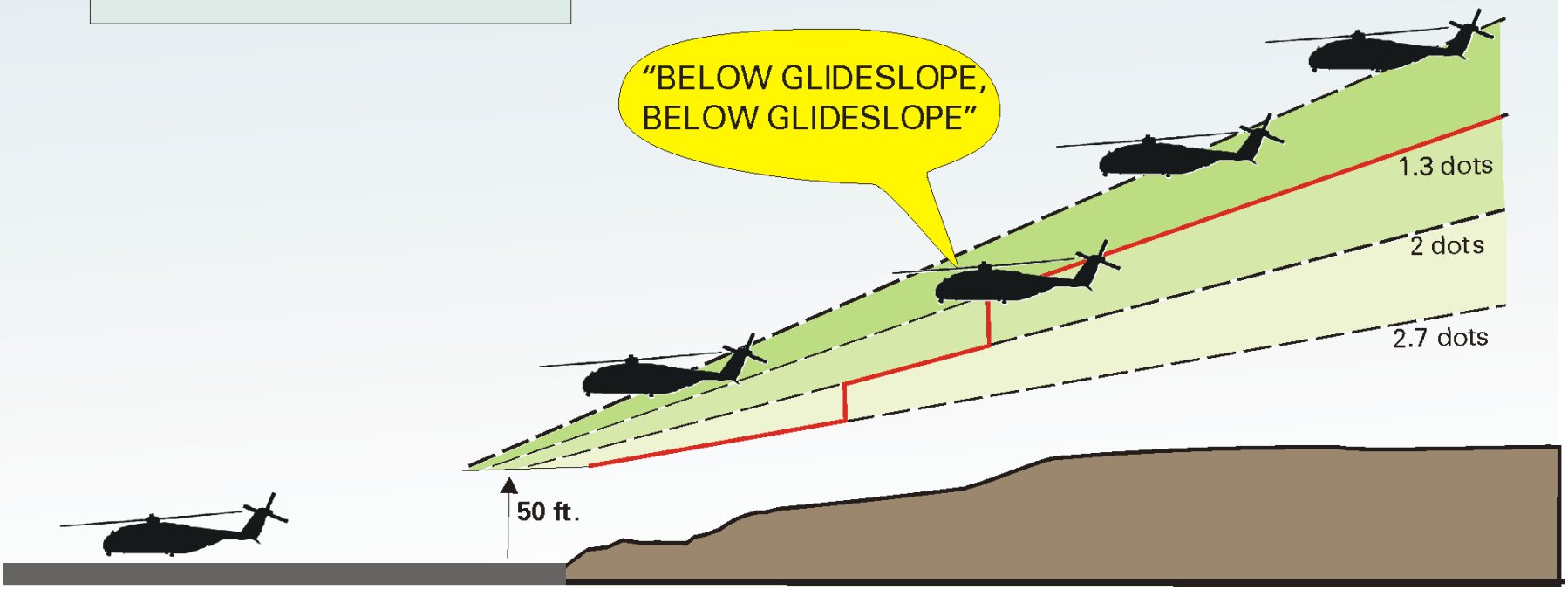
Glideslope

GPWS

CH-53E/MH-53E Only

A valid glideslope signal
Radar altitude < 1000 ft.
Within 3 dots horizontally of the localizer
A descent rate > 250 fpm.

GPWS ALERT



Glideslope

GPWS

This alert (CH/MH-53Es only) is issued whenever the aircraft receives a valid glideslope input, the altitude is less than 1000 feet, the aircraft is within three dots horizontally of the localizer front course, and descends below the glideslope limits set in the GPWC. The glideslope alert is issued while descending through 1000 -150 feet when the aircraft is 1.3 dots below the glide slope; at 100 feet when the aircraft is 2 dots below the glideslope; and at 50 feet when the aircraft is 2.7 dots below the glideslope as read on the ILS indicator.

Aural alert ***"BELOW GLIDESLOPE BELOW GLIDESLOPE"***
Alert repeated every 3 seconds.

Visual alert ***GPWS ALERT lamp on the Caution Advisory Panel illuminates and stays lit.***

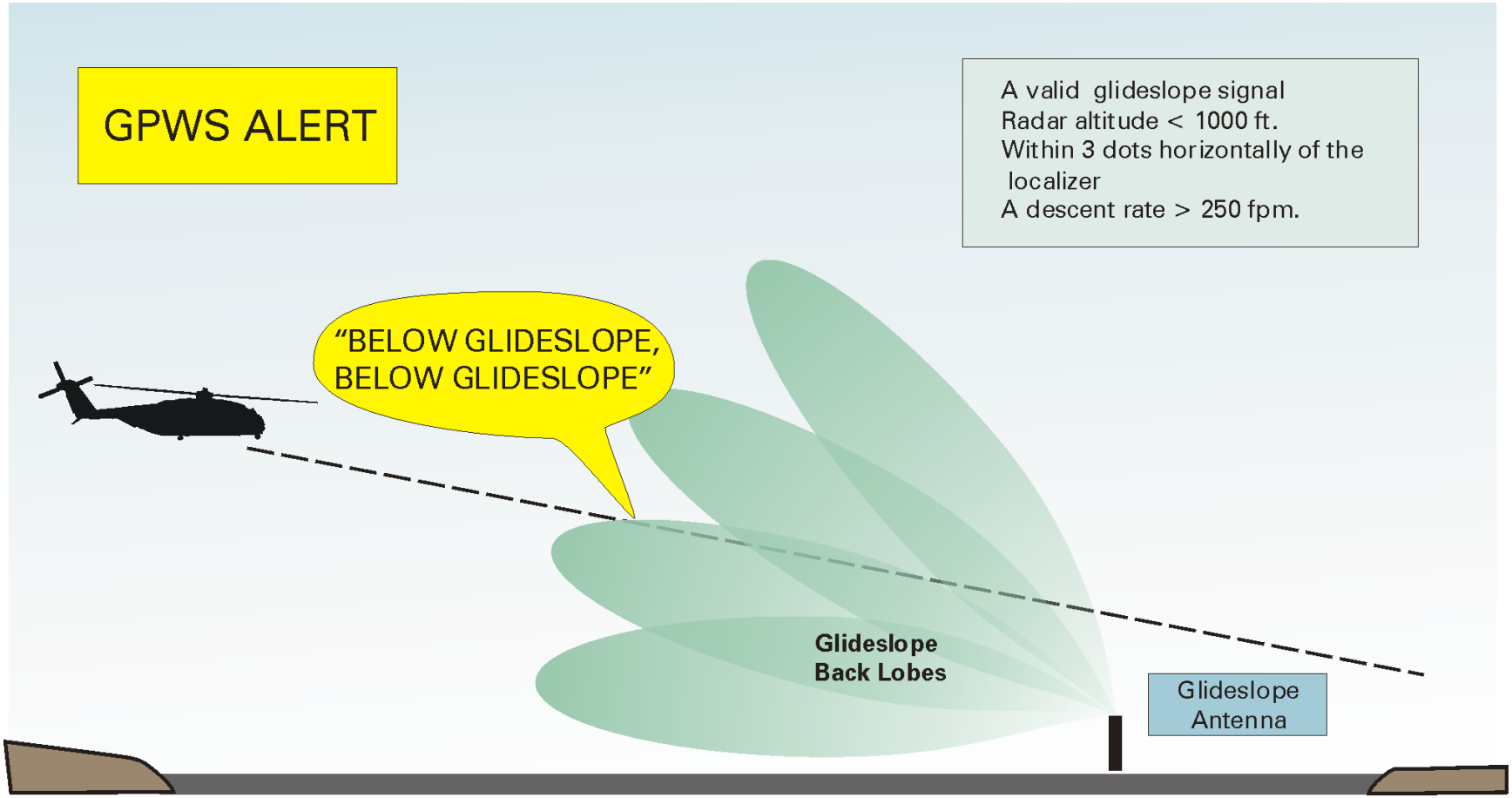
Re-arm Condition ***Re-intercept the glide slope. The ALERT lamp turns off.***

Note: The MH-53E has a back course selectable input installed that can be used to inhibit potential back course "Below Glideslope" warnings when flying back course approaches.

Glideslope

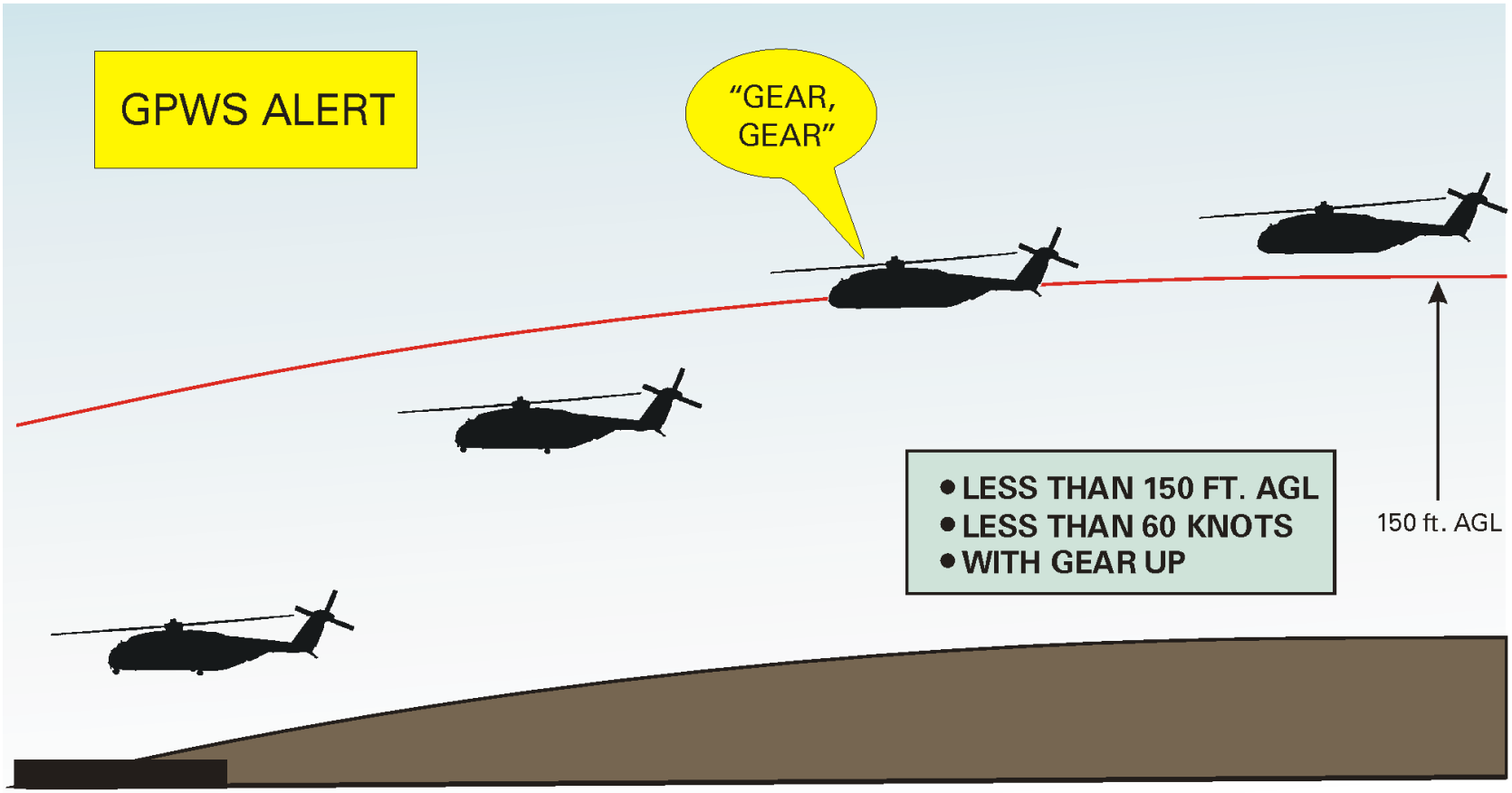
GPWS

CH-53E Only; MH-53E HAS BACKCOURSE SELECT



Landing Gear Up

GPWS



Landing Gear Up

GPWS

This alert (Applicable only to CH/MH-53 series aircraft) is issued whenever the GPWS landing gear up criteria is violated. This alert is enabled when the aircraft is in the air and either of the following occurs:

1. Radar altimeter signal is valid, aircraft less than 150 feet AGL, Indicated Air Speed (IAS) is less than 60 knots, and the landing gear is up.

Aural alert ***"GEAR GEAR"***

Alert is repeated every 3 seconds.

Visual alert ***GPWS ALERT lamp on the Caution Advisory Panel illuminates and stays lit.***

Re-arm Condition ***Gear is lowered, or radar altitude => 150 feet AGL, or IAS => 60 knots. The ALERT lamp is turned OFF.***

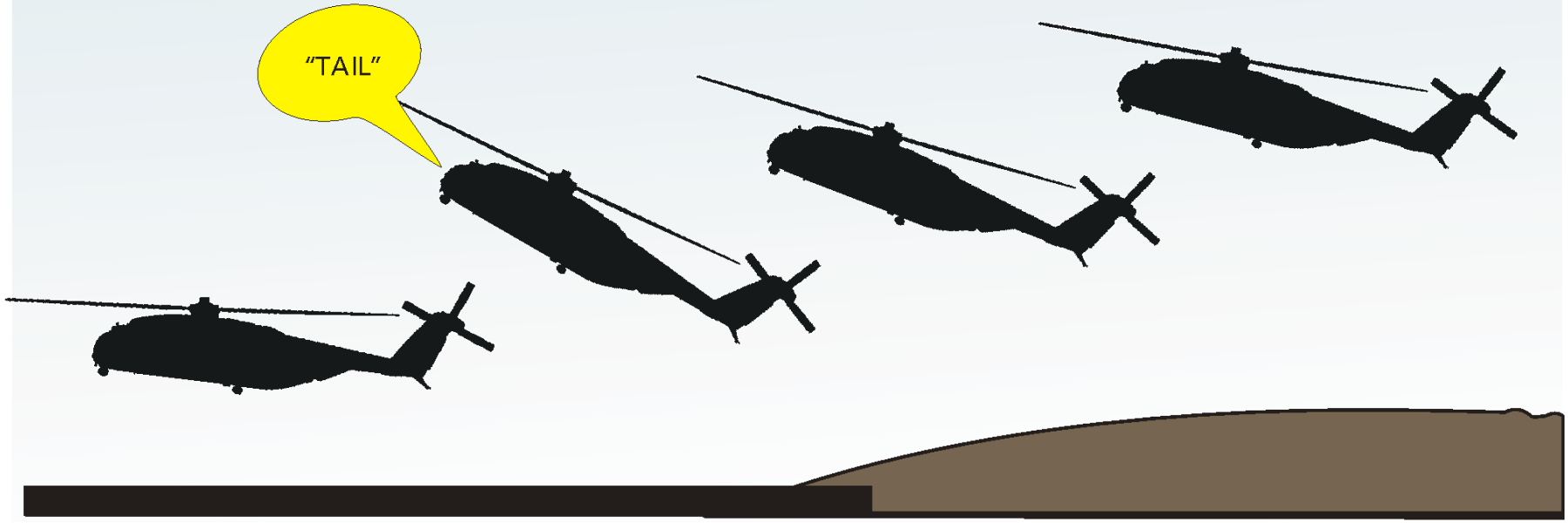
* Note: Alert can be deactivated by using the pre-existing landing gear up warning light. GPWS then reactivates the alert when IAS => 60 knots or when the aircraft descends below 15 feet AGL.

Tail Strike

GPWS

GPWS ALERT

AIRCRAFT VIOLATES THE PITCH ANGLE VERSUS ALTITUDE CRITERIA



Tail Strike

GPWS

The tail strike alert is issued whenever a potential tail strike is detected. This warning is enabled when the aircraft violates the pitch angle versus altitude criteria which closely follows the CH-53E NATOPS. Applicable only to the H-53 aircraft.

Aural alert "TAIL"

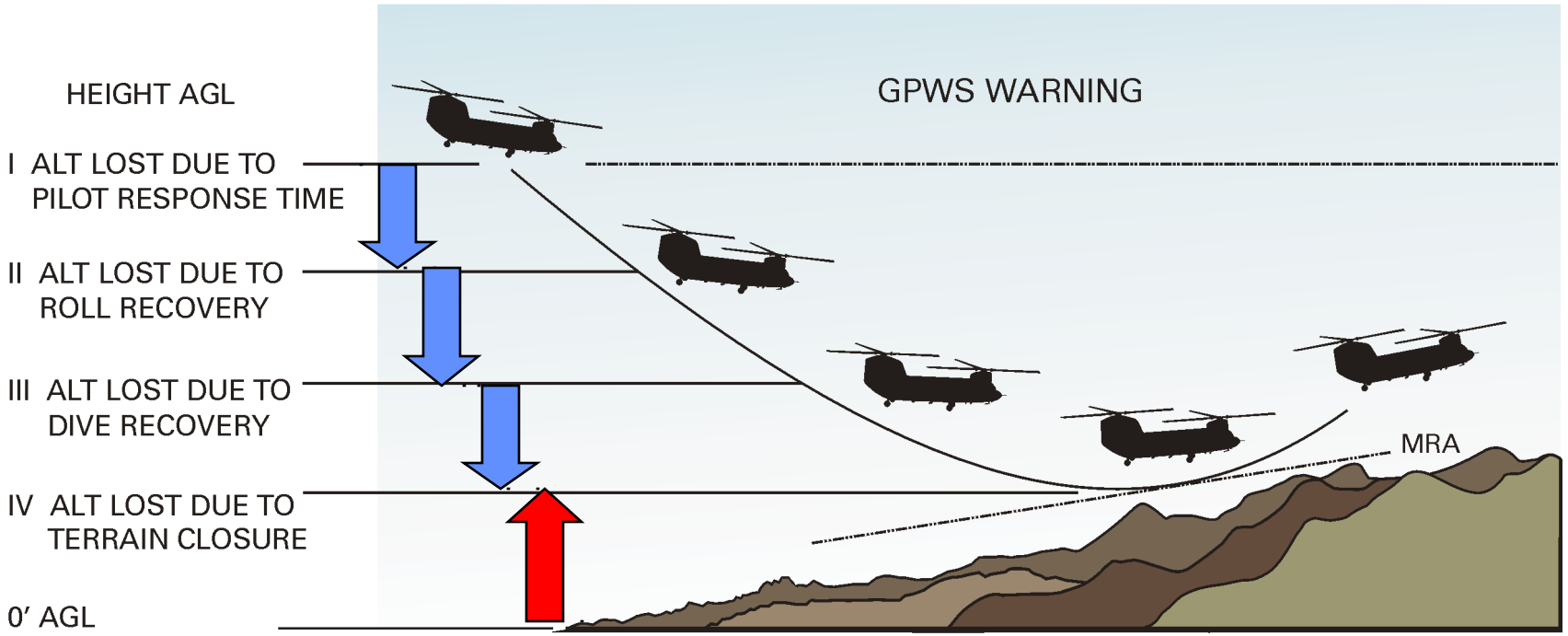
Alert issued once.

Visual alert GPWS ALERT lamp on the Caution Advisory Panel illuminates and stays lit.

Re-arm Condition Initial warning conditions no longer violated. The ALERT lamp is turned OFF.

Fixed Minimum Recovery Altitude (FMRA)

RECOVERY ALTITUDE LOSS = I + II + III + IV


HEIGHT AGL
GPWS WARNING
I ALT LOST DUE TO PILOT RESPONSE TIME
II ALT LOST DUE TO ROLL RECOVERY
III ALT LOST DUE TO DIVE RECOVERY
IV ALT LOST DUE TO TERRAIN CLOSURE
0′ AGL
MRA

* ALL VALUES CONTINUOUSLY COMPUTED BY GPWS 10 TIMES PER SECOND
* GPWS MODELS HELICOPTER UNIQUE CHARACTERISTICS

Fixed Minimum Recovery Altitude (FMRA)

GPWS

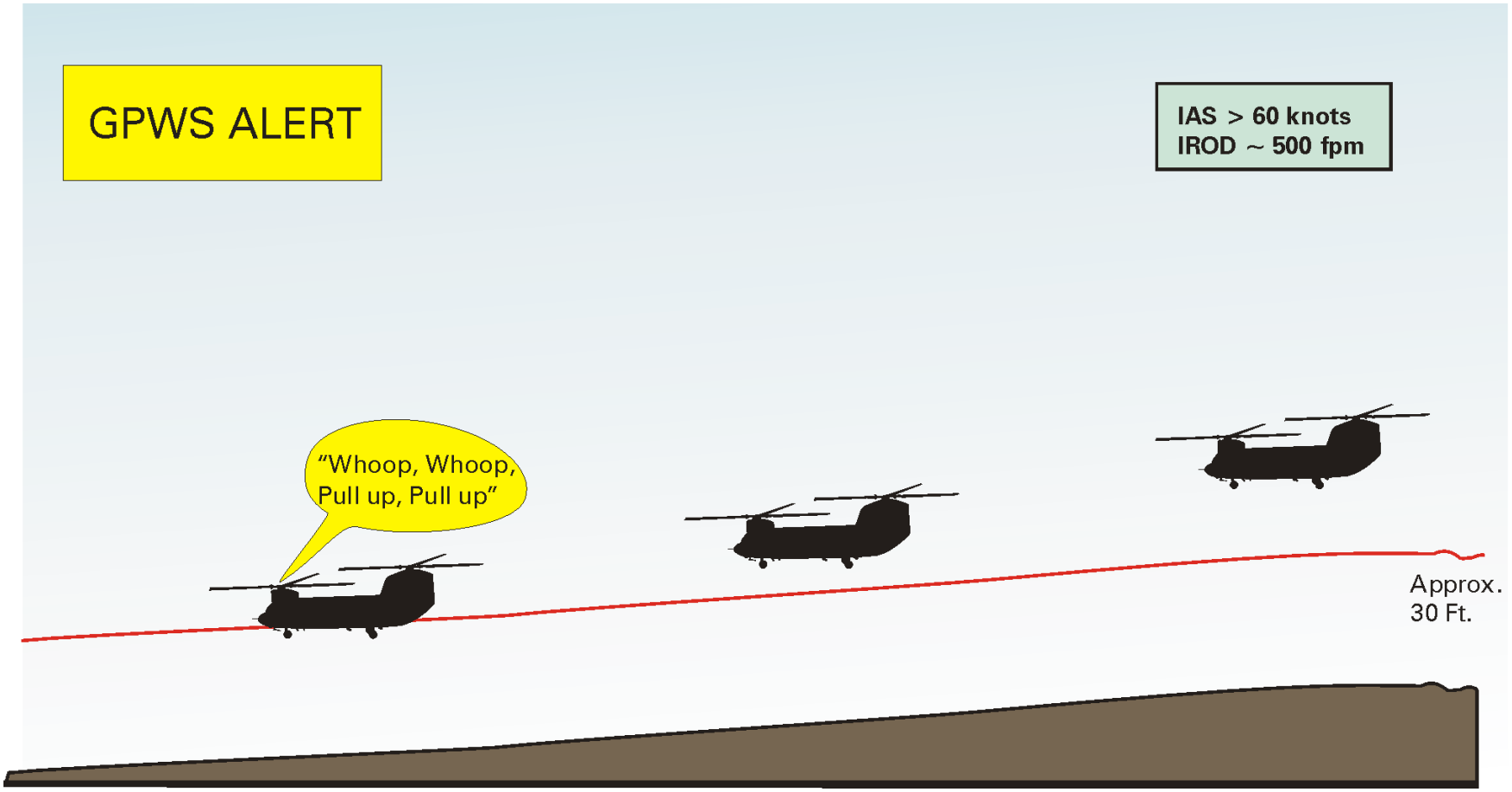
[Impending CFIT]

This warning is issued when the GPWC computes that the Predicted Recovery Altitude (PRA) for the aircraft is equal to or less than Minimum Recovery Altitude (MRA) over three iterations. Each iteration takes one tenth of second. The MRA is set at 0 feet Above Ground Level (AGL). This warning is enabled whenever the aircraft is not in the climbout or landing state.

Aural warning	***"WHOOP WHOOP PULL UP PULL UP" Warning issued once.***
Visual warning	***GPWS ALERT lamp on the Caution Advisory Panel illuminates and stays lit for the CH/MH-53 series aircraft. There is no indication for the CH-46E aircraft .***
Re-arm Condition	***Aircraft has a positive rate of climb and climbs through 50 feet AGL. The ALERT lamp is turned OFF.***

Slow Descent

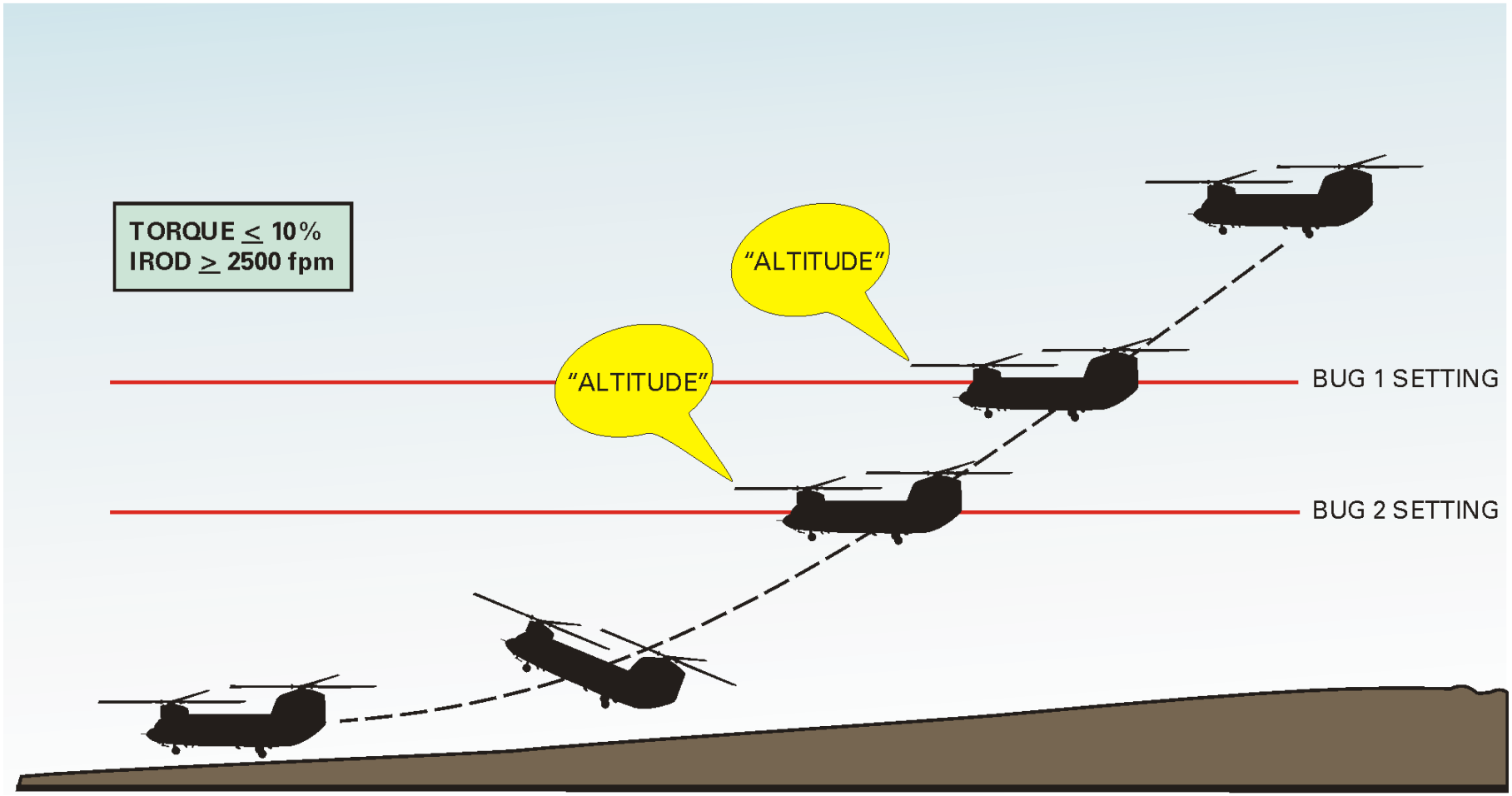
GPWS



Autorotation

GPWS

"ALTITUDE" CALLOUT IS A NON-GPWS FUNCTION



Autorotation

GPWS

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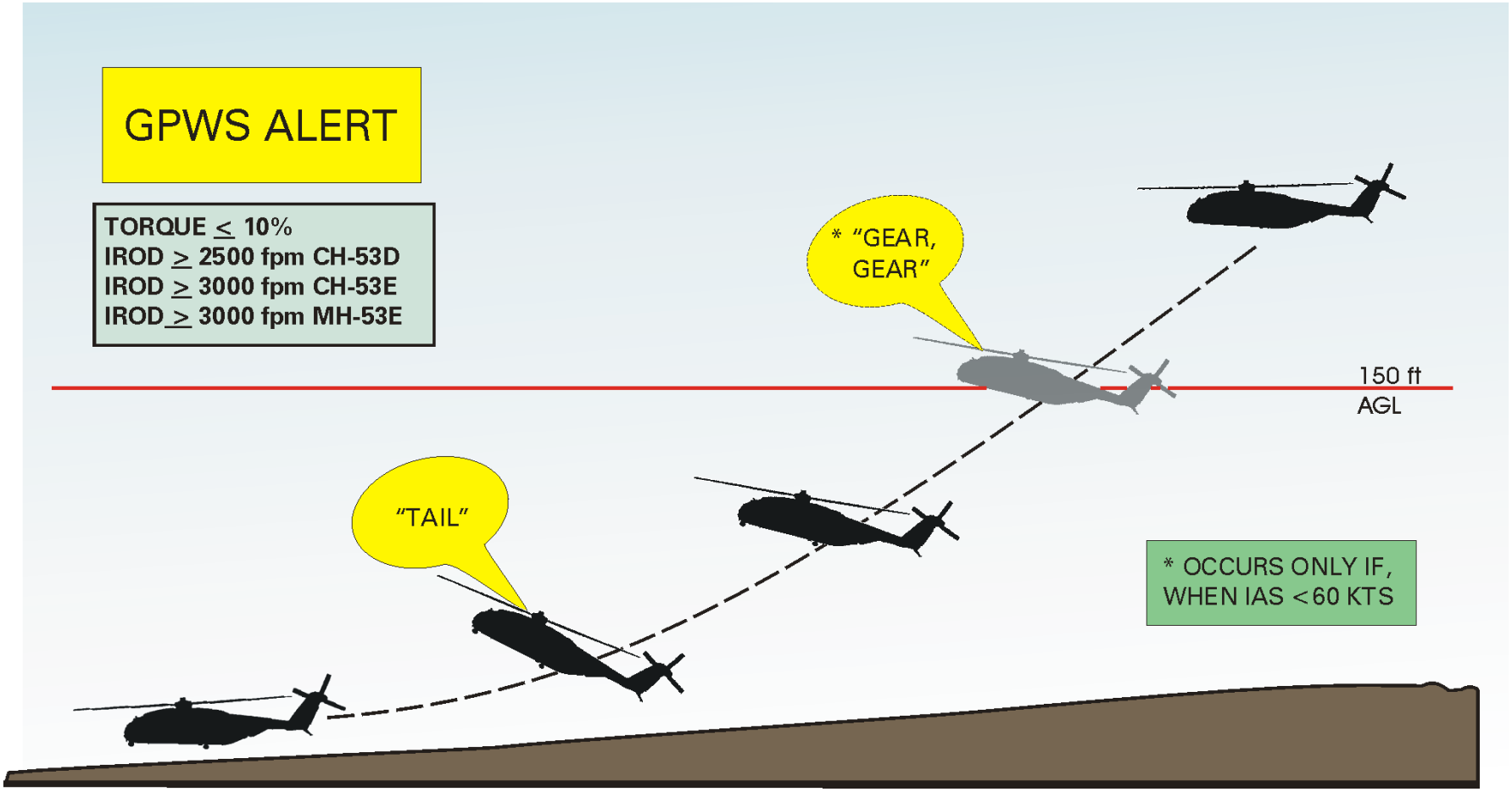

GPWS ALERT
TORQUE ≤ 10%
IROD ≥ 2500 fpm CH-53D
IROD ≥ 3000 fpm CH-53E
IROD ≥ 3000 fpm MH-53E
* "GEAR, GEAR"
150 ft AGL
"TAIL"
* OCCURS ONLY IF, WHEN IAS < 60 KTS

Aural Advisories

GPWS issues aural advisories that are not warnings. These occur during the initial power up and when built-in-test results are expressed or accessed.

At power-up, with a normal, operating GPWS, one hears, “Whoop Whoop, Pull Up, Pull Up . . . Bank Angle, Bank Angle . . . GPWS Ready”. This is to give the crew familiarity with the tone and volume of a typical set of warnings without startling them.

Other advisories are issued when IBIT and CBIT are active and detect a fault and when fault histories are requested.

Initialization BIT (I-BIT)

The GPWC will perform I-BIT upon application of primary power, to verify the operational status of the system. The I-BIT takes up to 20 seconds.

After I-BIT is completed, the results are as follows:

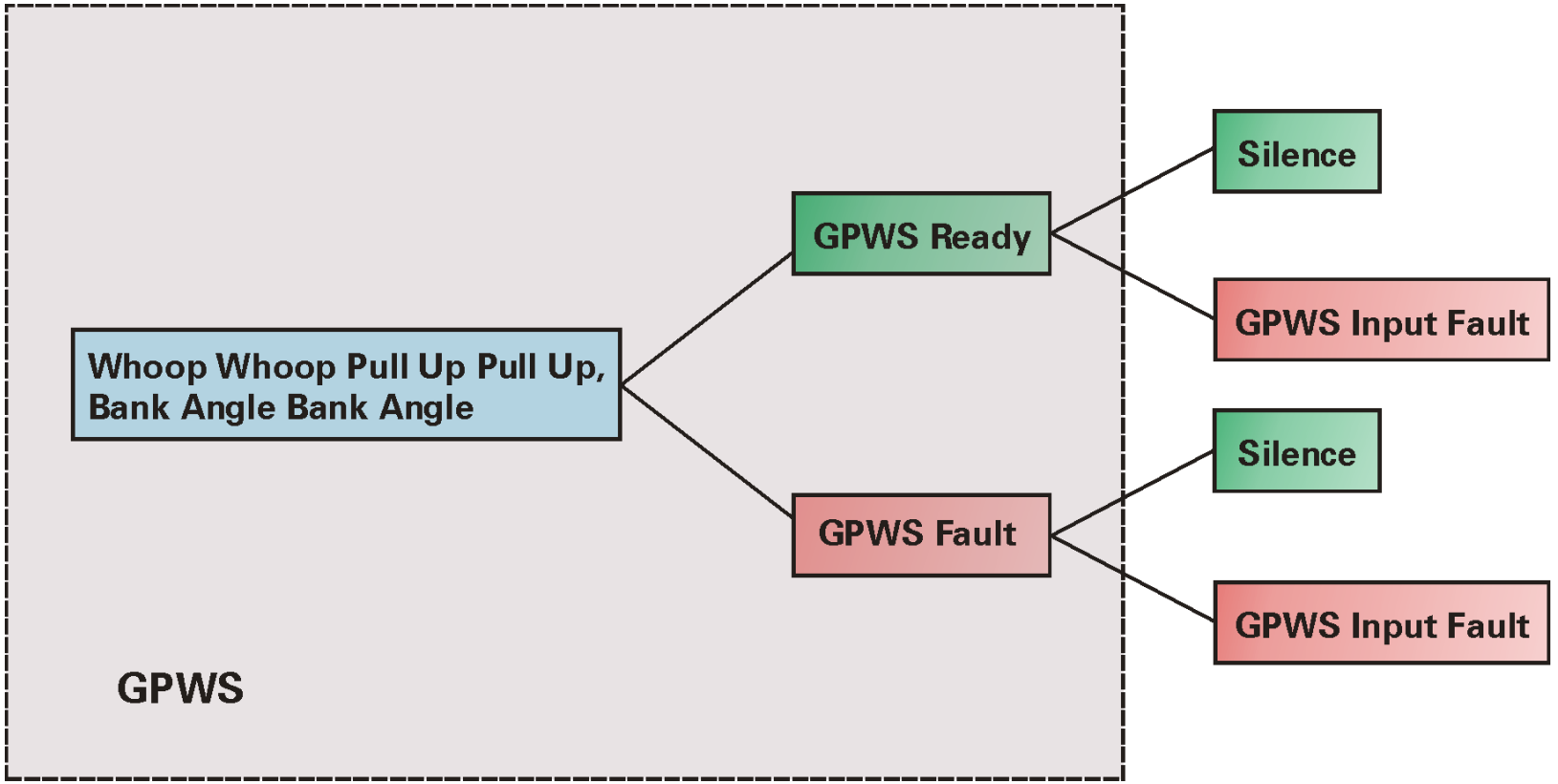
1. **“Whoop Whoop Pull Up Pull Up”, “Bank Angle Bank Angle”** is heard**,** then **“G” “P” “W” “S” “READY”,** or **“G” “P” “W” “S” “Fault”,** or **“G” “P” “W” “S” “Input Fault”** is heard.

2. Illumination of the INOP lamp on the Caution Advisory Panel indicates failure for the CH/MH-53 series aircraft.

3. “Go” or “No Go” status is displayed on the CDNU for the CH-46E aircraft.

If GPWS Fails BIT in the air:
(1) No voice messages are annunciated, (2) Continuously lit INOP lamp for the CH/MH-53 series aircraft or continuous “No Go” status on the CH-46E CDNU.

Initialization BIT (I-BIT)



External to GPWC

GPWS BIT Messages

Annunciation Messages

GPWS Fault
GPWS Input Fault One
GPWS Input Fault Two
GPWS Input Fault Three
GPWS Input Fault Four
GPWS Input Fault Five
GPWS Input Fault Six
GPWS Input Fault Seven
GPWS Input Fault Eight

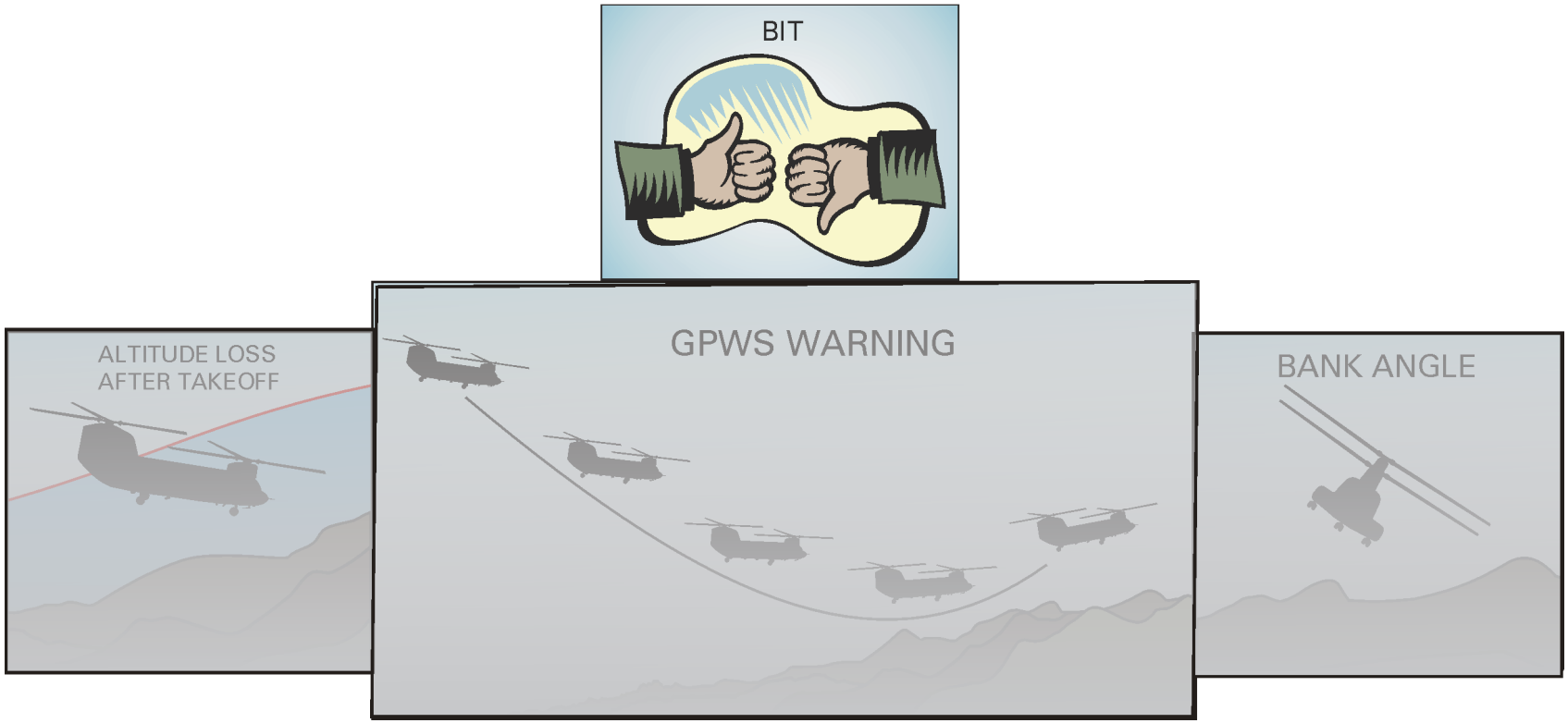
GPWS Input Fault Nine
GPWS Input Fault One-Zero

Invalid Sensor Input

GPWS Processor
Radar Altimeter
Internal Normal Accelerometer
Displacement Gyro
Air Data Computer
Barometric Altitude
Barometric Altitude Rate
Indicated Airspeed
Weight-On-Wheels/
Landing Gear Position
Configuration Pins
Engine Torque

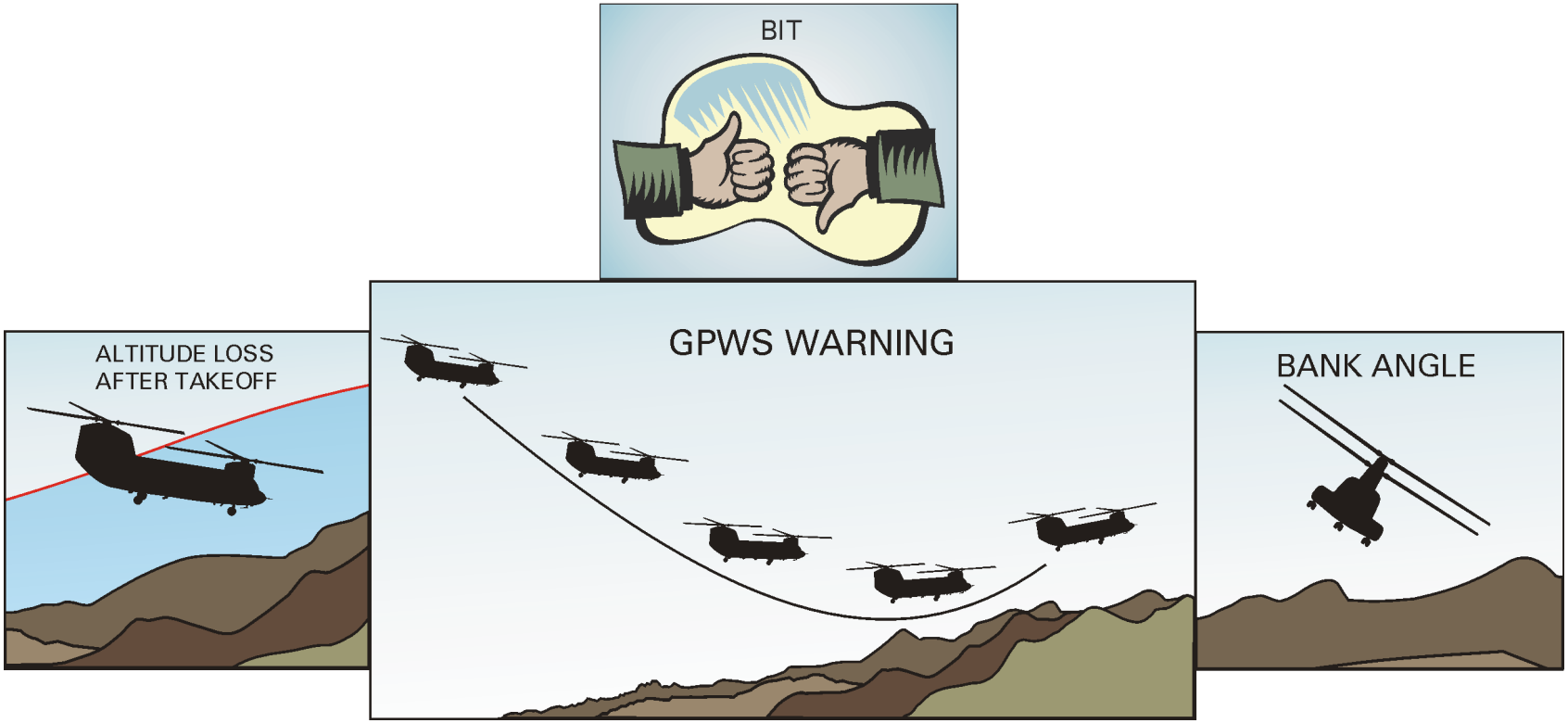
ON GROUND CH-46E

GPWS



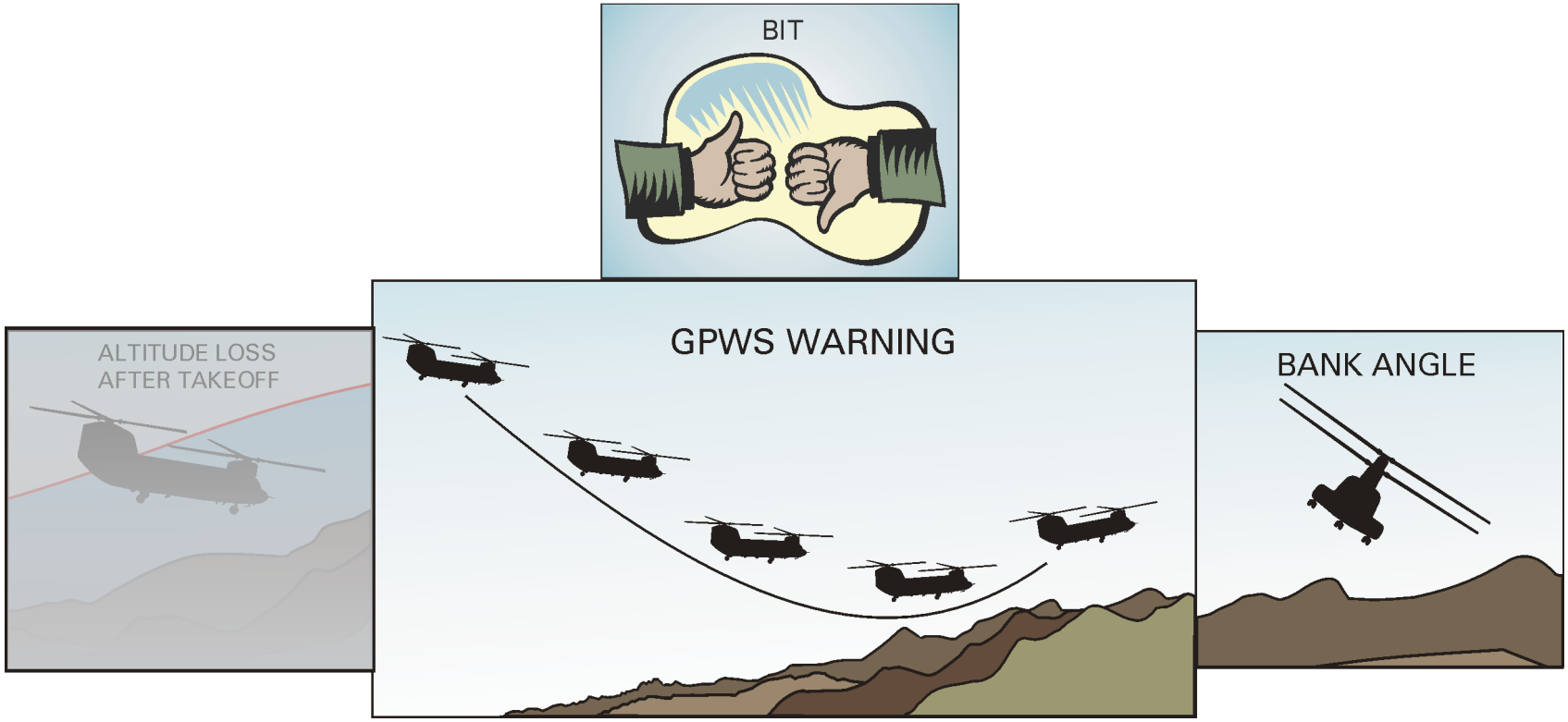
CLIMBOUT CH-46E

GPWS



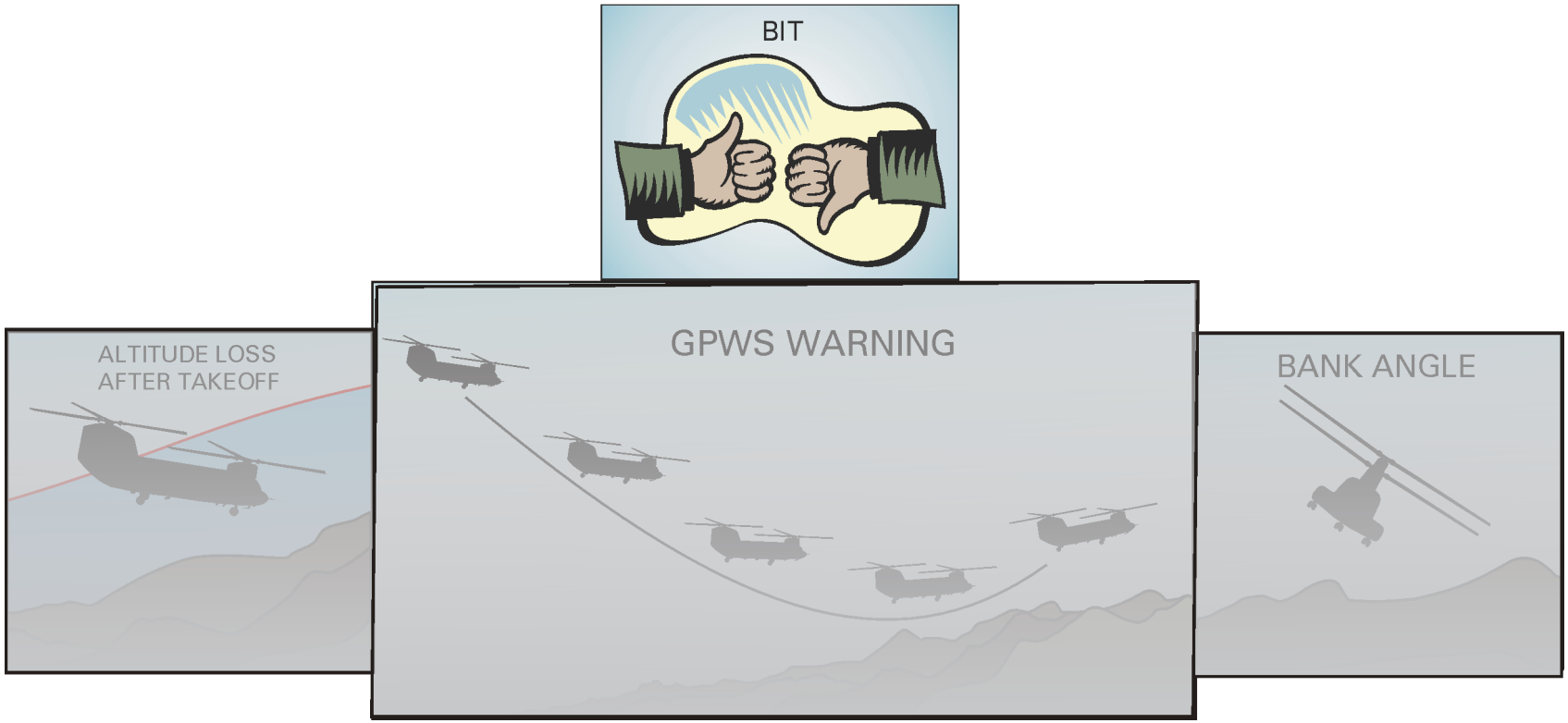
FLIGHT CH-46E

GPWS



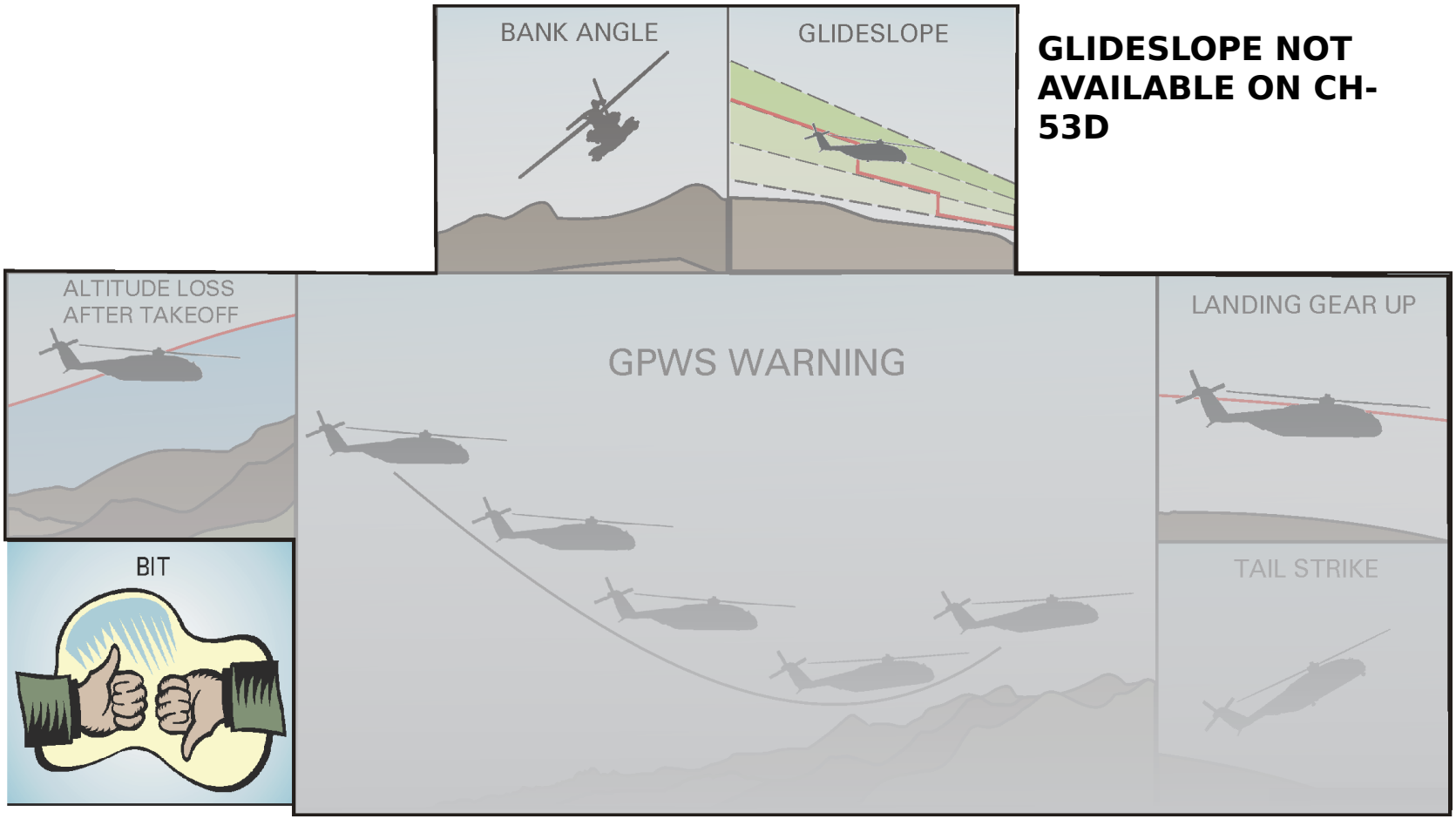
LANDING CH-46E

GPWS



ON GROUND CH-53D/E & MH-53E

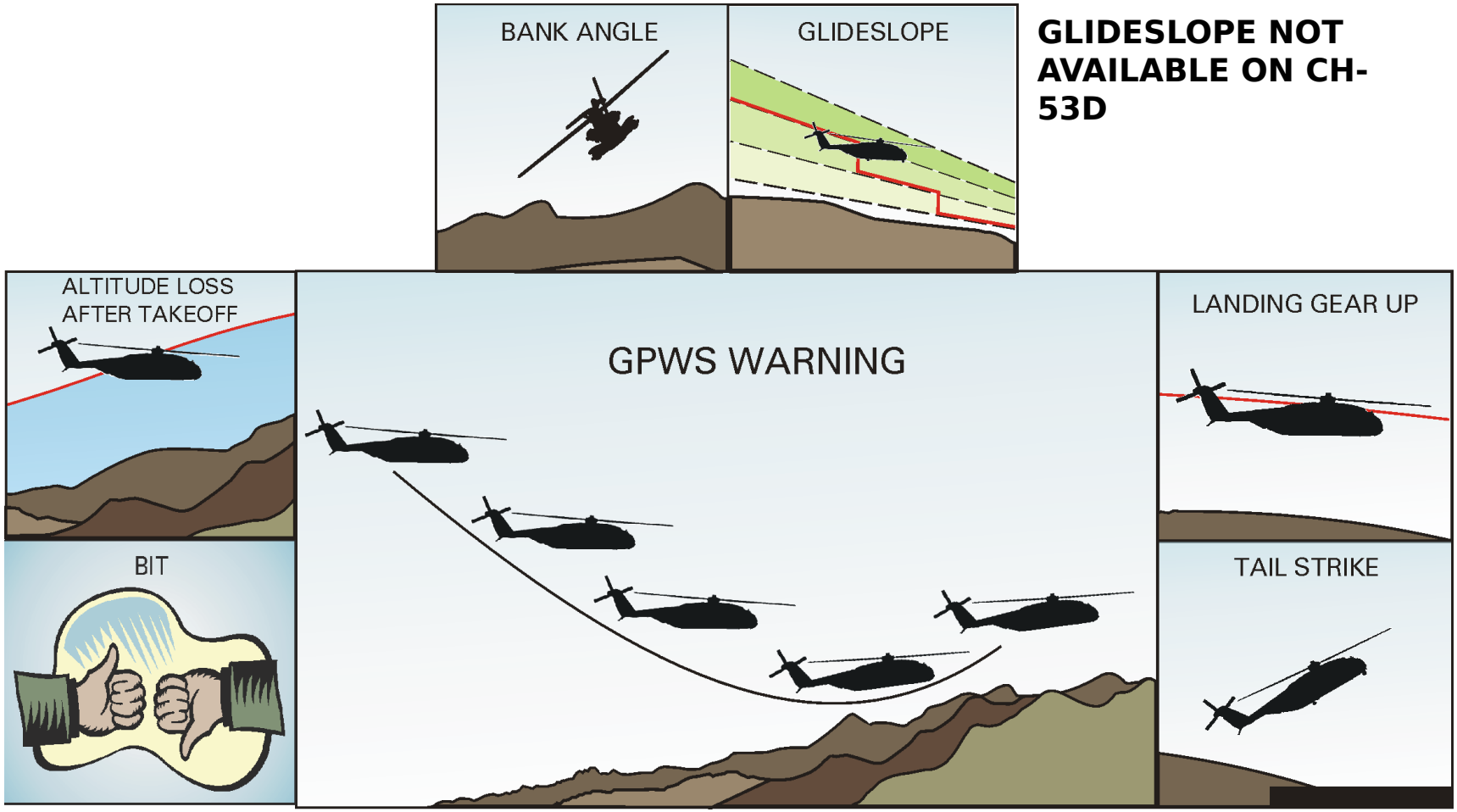
GPWS



GLIDESLOPE NOT AVAILABLE ON CH-53D

CLIMB OUT CH-53D/E & MH-53E

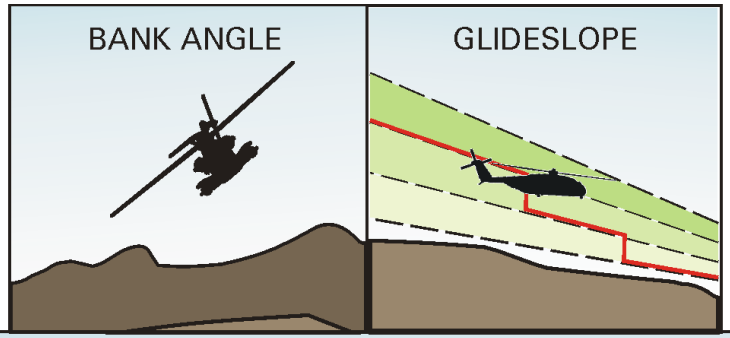
GPWS



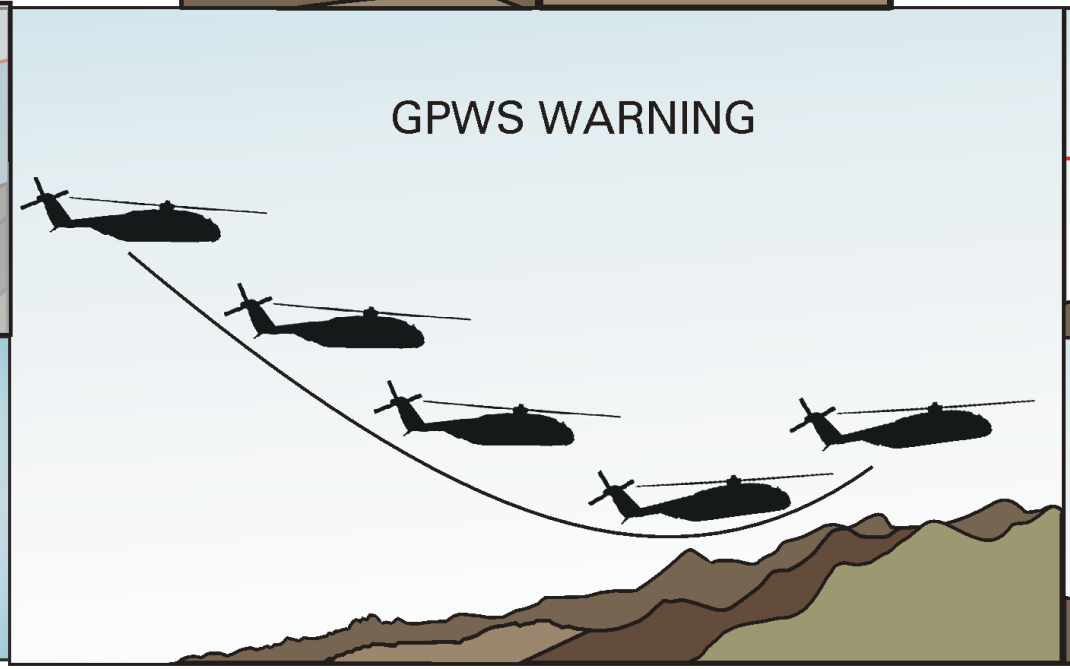
GLIDESLOPE NOT AVAILABLE ON CH-53D

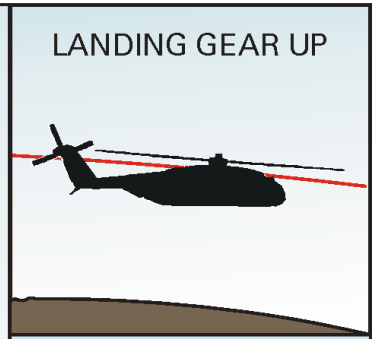
FLIGHT CH-53D/E & MH-53E

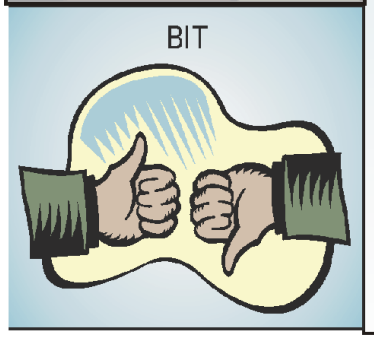
GPWS

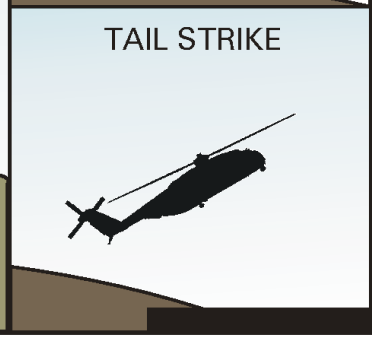


GLIDESLOPE NOT AVAILABLE ON CH-53D



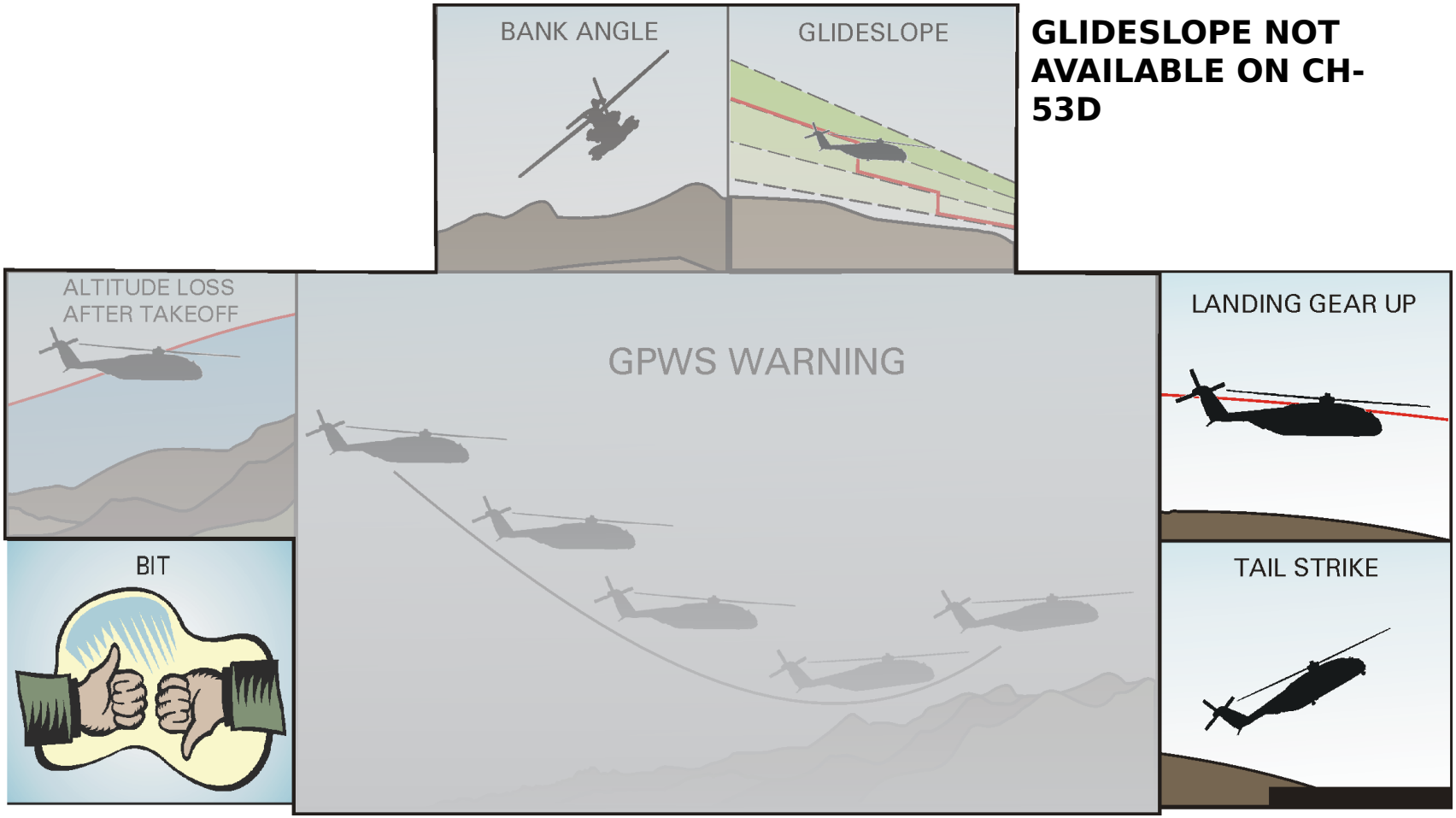






LANDING CH-53D/E & MH-53E

GPWS



GLIDESLOPE NOT AVAILABLE ON CH-53D

Operational Characteristics Matrix

GPWS

Operational Characteristics	CH-53D	CH-53E	MH-53E	CH-46E
Altitude Loss After Takeoff Warning	X	X	X	X
Predictive CFIT Warning	X	X	X	X
ILS Glide Slope Deviation Warning		X	X	
Excessive Bank Angle Warning	X	X	X	X
Landing Gear Warning	X	X	X	
Tail Strike Warning	X	X	X	
Slow Descent Warning	X	X	X	X

Limitations

Not Forward Looking

Cannot Detect Ultimate Height Of Projections Or Of Rising Terrain

Warnings Cannot Be Silenced to Avoid Garbling of Other Voice Traffic On ICS (Except for Gear Warning In CH-53E/MH-53E/CH-53D)

Nuisance “Below Glideslope” Warnings When Conducting A Backcourse Localizer Approach Due To Undefined Antenna Lobes (Except On MH-53E)